QUARTERLY JOURNAL FOR TEACHERS OF SCIENCE IN THE CATHOLIC HIGH SCHOOLS

# *The* SCIENCE COUNSELOR

Volume V ★ Number 4 ★ Dec., 1939

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# The Science Counselor

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Volume V DECEMBER, 1939 No. 4

CONTENTS

SCIENCE AND THE WORLD CRISIS..... 94
*Rev. P. H. Yancey*

THE SCIENCE AND ENGINEERING FAIR OF THE AMERICAN INSTITUTE OF THE CITY OF NEW YORK..... 97
*Douglas W. Bowden, Jr.*

MOTIVATION OF A UNIT ON INSECTS..... 99
*Sister Mary Ida*

AN INTRODUCTION TO CRYSTAL CHEMISTRY.....100
*Charles W. Stillwell*

THE SCOPE OF GEOLOGY.....102
*Timothy C. May*

THE CORRELATION OF RELIGION AND SCIENCE IN THE TEACHING OF SCIENCE .....105
*Sister Mary Andrew*

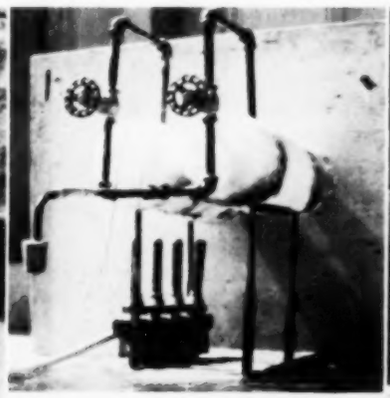
IGNACY MOSCICKI, THE CHEMIST.....106
*John F. Matejczyk*

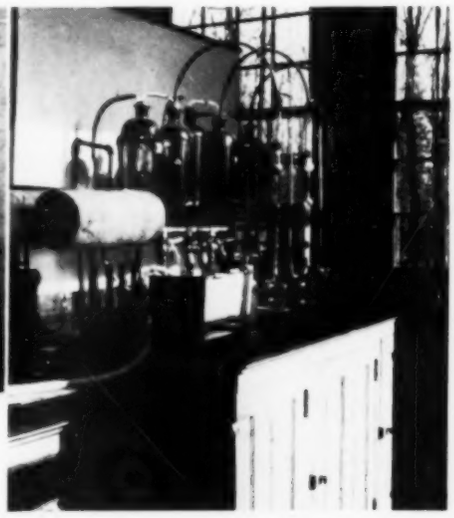
SCIENCE CONFERENCE .....107

NOTES ON CATHOLIC CHEMISTS.....108
*Sister M. Dafrose*

NEW BOOKS .....110

IN FUTURE NUMBERS.....113





WORKING MODEL OF COKE PLANT *to be demonstrated at the coming Duquesne University Science Conference by Brother D. John, F.S.C., LaSalle Hall, Ammendale, Md.*

# Science and the World Crisis

● **By Reverend Patrick H. Yancey, S. J., Ph. D.,** *(St. Louis University)*
DEPARTMENT OF BIOLOGY, SPRING HILL COLLEGE, MOBILE, ALABAMA

*This is a "MUST" article!*

*You cannot afford to miss it. Father Yancey here says important things—things that need repeating again and again.*

*It is doubtful if one will find a better statement of the relationship that should exist among theologians, philosophers, and scientists, and of the unfortunate results that are to be expected when each group does not keep within its proper field.*

*This paper formed Father Yancey's presidential address to the Alabama Academy of Science, delivered at its April, 1939, meeting and published in the Academy's "Journal" for June, 1939. It appears here with the permission of the author and the "Journal".*

*We are glad to give it the wider circulation it deserves.*

●

It seems to be pretty well agreed that we are in the midst of a world crisis. On every side we see wars or hear rumors of wars, and we are told that another World War, in comparison with which the last war was only a skirmish, is almost upon us. More important still, we see the pattern of civilization we had fondly considered, if not the best attainable, at least the most perfect that had so far been attained, and this at the cost of great sacrifices—threatened with destruction.

In such circumstances it is customary to seek something or someone on whom to lay the blame. In 1932 the Democrats blamed the Republicans, and in 1936 the Republicans and many Democrats blamed the New Deal; Hitler blames the Jews and the rest of the world blames Hitler. In a word, everyone has his own candidate for the office of scapegoat.

Among the things that have been most blamed for our ills is, strange to say, science. It has been said that science is a blame for war or, at least, for the horrendous type of war we have today, because it discovered the high explosives, airplanes and other machines of destruction that are used in modern warfare. It is also blamed for our economic misery because of the invention of labor-saving devices. As a result, some have gone so far as to suggest a "holiday" from scientific investigation. Of course, such an idea is fantastic. You might as well talk of damming the Gulf Stream as to talk of stemming the tide of human thought and inventiveness. And even if it were possible, it would not be desirable because of the violence it would do to the human spirit, to mention only one reason. It would set back civilization more than all the attacks of totalitarianism, and more than a war involving literally every nation of the earth.

Are we then to absolve science of all culpability for the ills of the world? Science, yes; because science in the broadest sense of the word is simply knowledge and knowledge is good. But even in its narrower sense of natural science it is still good. For, though this knowledge should be abused to do evil, as knowledge it is still good and, generally, the good effects more than outweigh the evil. Therefore, science cannot be blamed.

Can the same be said of scientists?

In my opinion it can, because not only have scientists contributed perhaps more than any other group to making the world a better place to live in, and to making life in it more certain and of longer duration, but also as a group they have done very little towards making the evil use of scientific discoveries that is supposed to have brought us to the present impasse. Very few of them have benefitted financially from their scientific discoveries and, consequently, have not been a factor in the unequal distribution of the goods of this world which, no doubt, is a part of our trouble. Very few of them have taken an active part in politics; hence, they are not responsible for our present political conditions. In fact, as scientists they have done a pretty good job, and far from being blamed they ought to be praised and better rewarded for their positive contributions to the welfare of humanity.

However, this does not mean that some scientists have not contributed towards creating the conditions which exist today. Of course the same can be said of clergymen and politicians and of any other group. But one of the reasons why we are not getting out of our present doldrums is, I believe, because each group is trying to lay the blame on some other group instead of striking its own collective breast and crying out with the children of Israel of old, "We have sinned." So I hope I may be pardoned if I make bold to point out some of the ways in which, to my mind, some of our fraternity may have been contributing causes to the present unsettled state of the world. I do this in the hope that by removing these obstacles we may make an even greater contribution to world peace and progress.

●

First of all, let me emphasize again that it is not as scientists that scientific men have done harm, but precisely when they ceased to be scientists and tried to become philosophers, theologians, politicians or something else; that is, when they left their own special field. Of course, knowledge can not be neatly wrapped up in separate packages labelled "science," "philosophy," "theology," etc., so that one who takes one field of knowledge for his specialty should be absolutely ignorant of all the others and never make use

of the contributions of another branch in pursuing his own. Quite the contrary. It is more likely that a man who has limited himself too exclusively to one field would not be an authority even in that field. In fact, this is the first charge I would make against some scientists, namely, that they have an altogether too narrow outlook.

With the great triumphs of natural science in the 19th century came a feeling of smugness on the part of some scientists that the world had been a pretty barbarous place until they came along. It was customary to refer to previous ages as "dark," though modern research has shown the falsity of this appellation for the so-called Middle Ages.

With some this was only a negative attitude. They simply ignored all other approaches to truth without positively denying their possibility. They were intellectual agnostics. Perhaps the best example of this kind of scientist was Charles Darwin. Never having had much formal education, he disliked most of that which was forced upon him, especially mathematics, than which there is no better discipline for the mind. As a result his mind became, as he himself confessed, "a kind of machine for grinding out general laws out of large collections of facts." The trouble was that the machine lacked several important cogs. One of these was a thorough grounding in logic, and he admitted a tendency in himself "to fill up wide gaps of knowledge by inaccurate and superficial hypotheses" because he held that in "scientific investigation it is permitted to invent any hypothesis, and if it explains various large and independent classes of facts it rises to the rank of a well-grounded theory." Hence, he has been called by his latest biographer, Geoffrey West, "a fragmentary man."

However, it was the followers of Darwin, such as Huxley in England and, especially, Haeckel in Germany, who became active propagandists for a new type of education which would dispense with most of the lore of the past and would concentrate exclusively on the facts and theories of natural science. They laughed with scorn at the ancient classics which had been the backbone of education up to that time. At first they met with opposition, but gradually their ideas prevailed and the old classical education gave way to the new scientific kind to such an extent that, today, the study of the liberal arts has become so neglected that the re-introduction of them into certain colleges as an experiment calls for nation-wide comment. Thus Mr. Walter Lippman found material for a most illuminating article on the "St. John's Program," that is, the return to a liberal arts curriculum at St. John's College, Annapolis, Md.

He writes:

> "When I was very young . . . I was taught that because applied science had revolutionized the arts of producing goods, the hopes of free men would be realized when everyone had learned about the experimental procedures of scientists and engineers. But I was unconvinced . . . because, though I had a speaking acquaintance with the methods of applied science, it was only too painfully obvious to me that I did not really understand the troubled times in which we live."

It was in this state of mind that he came across a book by Dr. James J. Walsh called *Education of the Founding Fathers*. This is his reaction to its thesis:

> "To my immense surprise I learned for the first time that these men who organized our liberties had followed a course of studies which comes down to us through the middle ages from the schools of ancient Greece. They had studied and had been drilled in the liberal arts, arts which were called liberal because they were what the 'liber homo,' that is, the free man must know if he is to be in fact free. . . . First it seemed to me odd, for I was a child of my generation, that the men who had made the modern world should have been educated in this old-fashioned way. And then I began to think that perhaps it was very significant that men so educated had founded our liberties, and that we who are not so educated should be mishandling our liberties and to be in danger of losing them. Gradually, I came to believe that this fact is the main clue to the riddle of our epoch, and that men are ceasing to be free because they are no longer being educated in the arts of free men."

He concludes:

> "There are those who see that the onset of barbarism must be met not only by programs of rearmament but by another revival of learning."

We who are engaged in education can contribute greatly to this revival by insisting on a well-rounded curriculum in our institutions even, or rather especially, in the training of science students. My own experience is that the student who has a good training in the classics and philosophy makes a better scientist than one who takes little but science.

●

The second charge would seem at first sight to be contradictory to the first, for it is that some scientists have not "stuck to their last" but have dabbled in other fields. In reality there is no contradiction, because the charge is not so much that scientists have invaded other fields as that they have done so without a proper appreciation of the basic principles of other disciplines. As has already been said, knowledge cannot be precisely divided into water-tight compartments. Hence it is impossible for the scientist never to encroach on other fields of knowledge. This is especially true of philosophy, and to some extent of theology. Natural phenomena are not isolated facts but have ultimate causes and form part of a system of some sort. Therefore it is asking too much of the scientist to limit himself to the gathering of facts and to let the philosopher have the exclusive right to theorize on them. The scientist is an intelligent being and his mind is just as avid of the ultimate why of things as that of the philosopher. But just as the scientist expects the philosopher to take his facts from the expert in the scientific field, so the philosopher expects that the scientist will not build up philosophical theories from

his scientific discoveries without due regard for the laws of logic.

Not to go too far afield, I shall limit myself to the life sciences in pointing out a few instances of such extravagations on the part of scientists. With the marvelous discoveries in biology of the last century, but especially with the impetus given to the already promulgated theory of evolution by the publication of the *Origin of Species*, a number of biologists thought they had solved not only the problem of species which, today, we who have at our disposal many more facts than they had, sadly realize is still with us, but also the problem of life and the riddle of the universe itself. In vain did other biologists, like Virchow and Oscar Hertwig, protest against the application of the basic tenets of Darwinism, such as "the struggle for existence" and "the survival of the fittest," to human affairs. It is a significant fact that Adam Sedgwick, Darwin's mentor in geology, predicted that if Darwin's rejection of the metaphysical and moral part of nature were accepted, "humanity . . . would suffer a damage that might brutalize it, and sink the human race into a lower grade of degradation than any into which it has fallen since its written records tell us of its history." Today, as I pointed out in the beginning of this talk, many feel that we are on the brink of just such a catastrophe. But it may be objected that there is no connection. Let us turn to history after the publication of the *Origin*, and see.

Karl Marx considered that the *Origin* gave him "a basis in natural science for the class struggle in history," and so was born communism. At the same time Nietzsche appealed to it for his idea of the superman, and thence sprang the old German imperialism and the new German Nazism. Moreover, the new industrialists of that day seized upon this teaching as justifying their policy of *laissez-faire*, which is the canker in the otherwise sound system of capitalism. All these and many other opposing political and economic theories stemmed directly from Darwinism. For, as West writes, "Think Darwinianly and you will act Darwinianly." That is what the rulers of Germany did before the last war, and we had hoped that that spirit had been forever crushed at the Marne and St. Mihiel only to find that it was the guiding principle of the participants at the Peace Conference of Versailles, except perhaps our own idealistic President.

Moreover, at that very time a new political and economic structure was being reared on the same foundation in Russia. Says an Associated Press dispatch from Moscow last March 19th *(New York Times)*: "Since the establishment of the Soviet regime, 1,700,000 copies of books by Darwin or by others propagating his teachings have been printed in the U.S.S.R. A museum has been founded bearing his name and dedicated to the popularization of Darwinism." And Professor L. S. Berg "was proclaimed unworthy of membership in the Academy of Sciences" because he "had written a monograph suggesting that the evolution of living organisms might arise from basic and preordained factors within the organisms (nomogenesis), rather than from natural selection, survival of the fittest and the like." And geneticists know that the International Genetics Congress which was scheduled to meet in Moscow this summer had to be transferred to Edinburg because of the Soviet's purge of geneticists.

This experiment, moreover, was not confined to Russia. For one of the basic tenets of the Bolshevik regime was the promotion of world revolution, and we saw not only the autocracies and monarchies of an earlier day—Russia, Germany, Austria, Spain—going down before its onslaughts, but also the strength of the democracies being sapped by it. But just as the barbarian invasions, which destroyed the Roman Empire, brought into being the modern nationalistic states, so the corroding influence of Communism created the counter-irritant of Nazism.

Miss Dorothy Thompson has contrasted the two systems as follows: "The conception of man as a product of economics is the essence of the philosophy of communism. The conception of man as a biological product, his destiny entirely determined by his racial chromosomes, is the essence of nazism." But, if, as I have shown, Marxian economics is an offspring of materialistic biology, the source of Nazi racism is to be found in the same.

Ever since the rediscovery of Mendel's Laws and the successful application of genetic principles in the improvement of plants and animals, we have been reproached for obscurantism and traditionalism because we did not use the same methods for improving the human stock. As Professor H. S. Jennings has pointed out:

> "There is no obstacle in the known principles of genetic science to the production of such a result, provided we can decide what qualities we wish to conserve in our human stock, and provided that the necessary methods are applied with the necessary thoroughness for the necessary length of time . . . To bring this about, to improve the human stock as cattle have been improved, a practical breeder must be placed in complete control, with instructions to fear not God neither regard man, in the execution of his project."

Well, the Nazis have met both challenges. They decided that the kind of human stock they wanted to conserve was the so-called Aryan, and they placed in charge a breeder who certainly has shown no fear of God nor regard for man. Nevertheless, several American geneticists have expressed themselves as highly interested in the results of the experiment.

●

The last charge to be made against some scientists concerns practical action. As a general rule the majority of scientists like nothing better than to be left alone to pursue their researches and, in turn, they do not busy themselves with the affairs of others or project themselves into activities foreign to their work, such as politics. Indeed the traditional picture of the scientist is that of a retiring, rather incommunicative individual, so wrapped up in his studies that, like Mel-

*Continued on Page One Hundred and Twelve*

# The Science and Engineering Fair of the American Institute of the City of New York

• **By Douglas W. Bowden, Jr.**
STUYVESANT HIGH SCHOOL, NEW YORK CITY

*Students in Catholic high schools, as well as those in other private and public schools, are invited to display the best of their science projects at the annual Fair that is here described. The "Announcement" mentioned at the end of this article gives complete information concerning the necessary procedure.*

*For the benefit of students living at a distance from New York City, local science fairs are being arranged in a number of cities. Participation in such exhibitions will stimulate the interest of pupils in science.*

*Teachers who are already supervising the construction of exhibits for the 1940 Duquesne University Conference should keep in mind the New York Fair and the local exhibitions as well. In 1939, some of the Pittsburgh exhibits later won prizes at the New York Fair.*

●

*A prize winning exhibit at the Science Fair*

The announcement of the twelfth annual Science and Engineering Fair is eagerly welcomed by thousands of embryo scientists throughout Greater New York. Even outside this area efforts in home laboratories will be stimulated, for in recent years entries from Pennsylvania, Connecticut, and Rhode Island have won coveted first prizes.

The Fair is a collection of exhibits, prepared by boys and girls, to illustrate various scientific truths and principles. The children must be between the ages of twelve and eighteen, but they need not be members of a club affiliated with The American Institute Science and Engineering Clubs. The entries are made through the school that the children attend, for it is necessary that the principal of the school vouch that the exhibits offered by the pupils of his school are the work solely of these pupils. In judging a project, consideration is taken of the age and the number of pupils engaged in a project.

Over five hundred exhibits are presented each year. Two to three thousand dollars are distributed in prizes annually, to be used by the recipients to further their scientific work. The largest single award is twenty-five dollars for an exhibit prepared by a group of children. However, one exhibit may be awarded several prizes. Exhibitors who are members of The American Institute Science and Engineering Clubs receive larger awards than non-members. The money for these awards comes from the state of New York, for this is the County Fair for New York County!

How this came about forms an interesting story, going all the way back to 1828 when The American Institute was organized to encourage the manufacturers and inventors of our young Republic. It was at the Institute's industrial expositions that the Morse telegraph, a Hoe press, a Mason and Hamlin organ, and the McCormick reaper, won recognition and were awarded prizes. As American industry developed, specialized shows such as the Auto Show, the Motorboat Show, and the Horticultural Show were created.

The American Institute felt that its purpose in this field was accomplished and that its aid was no longer needed. Naturally enough, it had been impressed with the major part that science had played in this industrial development. The Institute felt that not enough attention had been paid to the effects of science upon our social life. It felt that children should be made conscious of the influence of science in their lives.

By 1928, the importance of extracurricular activities in education had begun to be appreciated. Experiments in the project method had shown the value of this approach. Most schools had science clubs. Some of them were of the finest type, under competent leadership. Others were fumbling along without efficient guidance. The American Institute saw its opportunity to unite these various lines of activity into a vital organization

that would encourage the development of the scientific method among the youth of the nation as well as bring before the public the accomplishments of science. So the Science and Engineering Clubs of The American Institute were organized.

Any group of at least four children with an adult sponsor may be admitted to the junior activities of the American Institute on the payment of dues of ten cents per member. They receive club buttons and may enroll in the free science courses provided by the Institute. The Institute arranges for speakers for club meetings, and makes suggestions for interesting club programs. It even provides, for the asking, a booklet full of suggestions from veteran club sponsors on how to organize a science club. A monthly newspaper, "Science Observer", is published and sold at a nominal charge. Just this summer an agreement was reached with the well known "Science Leaflet" so that it becomes another official organ of the clubs.

The Institute felt that the chief weakness of individual science clubs is their limited appeal. Only relatively a few become acquainted with the achievements of science. The experiences of one club are unknown to another. If the clubs could only get together to discuss their problems and demonstrate their successes, if the boys and girls working in their home workshops could see what other boys and girls in similar workshops were doing, the encouragement to further endeavor as a result of the interchange of ideas would be most fruitful. At least, so the Institution thought. A Science Congress and a Fair were created. Space does not permit describing the Congress other than to say that it is conducted along the same lines as the meetings of the American Association for the Advancement of Science, with special speakers and sectional meetings for the various branches of science.

The Science and Engineering Fair will take place during the week of April 14-20, 1940. The American Museum of Natural History in New York City furnishes one of its great halls for the exhibit. The State of New York provides funds from its appropriation of State Fairs, as this Fair is a continuation of the industrial Fairs conducted by the Institute since 1828. Last year the state representative gave the Fair an A-1 rating among the accredited fairs of New York State.

*An attractive exhibit from Aldrich High School, Lakewood, R. I.*

A booklet announcing the Fair is sent out each September to the member clubs. Anyone else may secure one by writing to The American Institute. The booklet describes the aims of the Fair and outlines the various classifications in which exhibits may be entered. Regulations concerning size of exhibits, number of exhibits permitted from one school, time of delivering exhibits, regulations concerning the construction of them, are all contained in this booklet. The criteria for judging and the amount of awards are also stated.

To emphasize the idea that science is working for the common good and to avoid partisan strivings amongst exhibitors, The American Institute seeks to make its awards on an absolute basis. The judges are free to make as many awards as they see fit. If several exhibits are of superlative merit in a particular class, several first prizes are given. On occasion, the offerings in a class have been mediocre, so no first prize has been awarded. A third of the judges are obtained from among college and high school teachers, an equal number from the various fields of engineering, and another third from interested laymen.

The results of these annual Fairs have surpassed the expectations of the Institute. An average of more than 500 exhibits have been offered annually. Last year more than eleven thousand visitors attended the Fair. Children and adults have shown the same eagerness to view the exhibits, to push buttons and pull levers. Girls as well as boys have shown great interest in the Fair. The girls' endeavors have been chiefly in the biological field. However, they enter several excellent chemical exhibits each year, and on one occasion the outstanding exhibit of the show was a Wilson cloud chamber constructed by a girl! Girls from Harren High School Commercial Annex were responsible for working models of a Diesel engine and an X-Ray apparatus, in 1939.

The prize money is being spent, as Fair sponsors hoped, on more science apparatus. One boy made a simple mercury vapor discharge tube, taking advantage of the vacuum at the top of a mercury barometer. With his prize money he purchased a mercury diffusion pump and attempted to obtain diffraction spectra from electrons! He didn't succeed, but he did learn a lot concerning the problems of high vacuum work. Not only has there been progress in individual research, but the children have learned to work in groups on a single project. Some projects have taken several years to complete. Valuable training in habits of persistence, patience, and thoroughness have been engendered. The schools have benefited by the increased interest in their science classes. Some of the projects have been so good that they have been made part of the permanent equipment of the schools.

The Westinghouse Company was so impressed with the achievements of the Fair that it offered space in its own World's Fair. Here may be seen a selected few of the prize winning exhibits. In the center of the room several boys and girls engage in typical activities of the science clubs. It is hoped that these demonstrations will

*Continued on Page One Hundred and Nineteen*

# Motivation of a Unit on Insects

● **By Sister Mary Ida, S. N. D.**
ST. MATTHIAS SCHOOL, HUNTINGTON PARK, CALIFORNIA.

*Teachers of biology who attended the 1939 Duquesne University Conference were captivated by Sister Mary Ida's manner of motivating a Unit on "Insects", using for her public demonstration an unrehearsed class of girls from the Notre Dame Academy, Cleveland, where Sister Mary Ida was then stationed.*

*So many expressions of warm approval followed the demonstration that we feel other teachers may care to know something of the method employed by this alert and progressive teacher. The brief outline here given is the one actually used. It merely indicates the procedure. We regret that we are unable to give the plan in greater detail. Even though incomplete, it may well be examined, studied, and imitated.*

*A new approach is as welcome and refreshing to the class as to the teacher.*

●

"Above all, develop in your students the ability to do critical thinking. They will then discover their own problems they want solved. They will show ability in discriminating and selecting data and they will know how to interpret them. They will be resourceful in attacking problems and flexible enough to criticize a line of action at any point. They should be able to revise their plan of procedure as soon as they discover fallacy or weakness. They will then have the ability to formulate and carry out a plan of action even though it must be based on inconclusive evidence and tentative judgment."—*Thayer.*

●

## OUTLINE OF THE PROBLEM-PROJECT METHOD

**I. Teacher's Approach:** This should be very carefully planned. Leads to problems should be suggestive but not stated. (This approach will spell success or failure in the first day's plan, depending upon the appeal it makes.

NOTE: Do not expect an immediate response after you make your approach. The student will need a few minutes of time if he is to formulate a thought-provoking problem.

**II. Class Expression:**

1. After the approach, the students will have been mentally aroused—they will spontaneously present their difficulties, wonders and desires.
2. The teacher then leads them to an organization of objectives. (Some student may volunteer to write the objectives as they are presented by the members of the class.) Choose as many objectives as in your estimation are necessary.
3. Direct the questions of the students so that they will formulate problems which either they alone or the class as a whole may solve.
4. Select the major problems the first day; subproblems will present themselves later.
5. Allow some student to act as Class Unit Bibliography recorder. The members of the class will show their books to this student who will keep a file box and make out cards on all the references contributed. (What an excellent bibliography for the instructor's next year's planning!)
6. One student will volunteer to be time keeper so that all major problems may be adequately summarized before the end of this first class period.
7. Another capable student will act as secretary. All who have suggested problems will report to her. Those who wish to engage in the solution of some problem will sign up for the same.
8. Since the complete time limit for the entire unit was arranged previously, the student-secretary and the teacher will organize a schedule, allowing the assimilation to progress as long as is deemed necessary.
9. During the next ten or fifteen class periods devoted to the solving of problems by the students, various fascinating activities will present themselves centering about those very problems. Among these might be: models, oilcloth charts, vivaria, mountings, souvenirs, poems, playlets, graphs, debates, definitely organized trips to Museums of Natural History, and, perhaps, a student may even invite some lecturer, who is an authority on that unit, to address the members of the class. These activities ought to be ingeniously suggested by the teacher. At times, a display of the work of previous classes will act as a doubly effective stimulus.
10. At the conclusion of the unit a thorough testing program on the major problems is carried out.

●

The above outline is merely suggestive. It is not intended to be a complete analysis of the entire method.

If further information is desired I will be glad to help enquirers to the best of my ability.

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*Continued on Page One Hundred and Eighteen*

# An Introduction to Crystal Chemistry

● **By Charles W. Stillwell, Ph. D.,** *(Cornell University)*
DENNISON MANUFACTURING COMPANY, FRAMINGHAM, MASS.

*Here is another out-of-the-ordinary article, designed primarily to open new avenues of thought. The average teacher knows little of crystal chemistry. Dr. Stillwell believes that even college freshmen should understand quite a bit about it.*

*Unfortunately, space permits the author to do little more than suggest topics for study. To attempt even a simple development would be a considerable task. This may be left to our readers. They will want to know, for example, why fibers have directional properties, whether or not the distinction between solid and liquid is absolute, the difference between adsorption and compound formation, and how certain of the properties of a metal depend upon its physical structure.*

*This paper contains material that was presented by Dr. Stillwell before the August, 1939, meeting of the New England Association of Chemistry Teachers at Burlington, Vermont.*

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Crystal chemistry is part of the mass of new material much of which everyone is agreed should be taught early in the chemistry curriculum. It is concerned with the structure of solids, and the influence of structure upon the properties of solids. Its purpose is to give the student certain generalizations descriptive of solids so that he may: (1) acquire an understanding picture of the nature of solids as a distinctive form of matter, and (2) predict the properties of solids rather than memorize them.

The elementary principles of crystal chemistry should, I believe, be included in the introductory course in chemistry. Certain features are particularly appropriate for the so-called cultural courses in chemistry. A more detailed knowledge of crystal chemistry affords a valuable background for teachers of introductory chemistry.

## An Outline of the Basic Principles of Crystal Chemistry to be included in Introductory Chemistry[1]

The elementary principles of crystal chemistry may be introduced to freshmen in chemistry with enough illustrative data to establish the general idea that the properties of solids do depend upon their structure as described in terms of the structural units and the forces holding them together.

In crystals, the units of structure—ions, atoms or groups of atoms—are arranged symmetrically in three directions.

Crystals may be built of ions held together by ionic forces, or of atoms held together by electron-pair or covalent forces. Bonds are not always of the extreme covalent or ionic type but may be mixed ionic-covalent bonds. In ionic and atomic crystals the simple molecule (e.g. NaCl) has no reality.

However, in the crystals of many compounds molecules do retain their identity. For example, hexamethylenetetramine forms body-centered cubic crystals. Each lattice point at the corners and center of the unit cube is occupied by an entire $C_6H_{12}N_4$ molecule. Such molecular crystals are weak because the building units are held together by weak van der Waals' forces. Most organic compounds form molecular crystals, as do other compounds or elements that are gaseous at ordinary temperatures.

Acid radicals generally retain their identity in crystals. The carbonate group is a definite building unit in $CaCO_3$ crystals.

The structure of a crystal is determined by the relative number, and the relative sizes of its building units, and by the nature of the forces holding them together. This first general rule may be developed in a convincing manner through the use of as much of a great deal of available illustrative material as time permits.

A perfected system of crystal chemistry would enable one to predict the properties of any solid. While the system is far from perfect at present, it is interesting to examine the relation between structure and some of the properties of ionic and covalent crystals. The following are illustrative.

The magnitude of the interionic attraction in ionic crystals affects their strength as measured by hardness, melting point, solubility and compression. It may be shown that as the force increases, either because of increasing unit charge or decreasing distance between the ions, these properties, which are a measure of strength, vary directly.

The properties of compounds with the mixed covalent-ionic bond suggest that this bond is a relatively loose bond as compared with the more exclusively covalent or ionic bonds. Among other things, a loose bond might be expected to produce a colored compound, and it is true that with the exception of compounds of the transition elements, all colored simple binary compounds do contain this mixed bond. That the color is due to the nature of the bonds between atoms rather

[1]It is impossible, in the scope of this summary to develop the ideas listed in the outline as they have and may be taught to beginners in chemistry. This was done in a series of papers some time ago: C. W. Stillwell, *J. Chem. Education* **10**, 590, 667 (1933) **11**, 159 (1934).
Additional, more detailed data may be found in *J. Chem. Education* **13**, 415, 469, 521, 566 (1936); **14**, 34, 131 (1937). Also C. W. Stillwell *Crystal Chemistry*, McGraw-Hill Book Co., New York 1938; R. C. Evans *An Introduction to Crystal Chemistry* The Cambridge University Press, 1939; W. T. Astbury *Fundamentals of Fiber Structure*, Oxford University Press, New York, 1933.

than to an inherent property of the atoms themselves may be readily demonstrated. The crystals with this mixed bond are also the photosensitive and photoconducting compounds. They have abnormally low melting points and are comparatively soft—further evidence of weak bonds.

### The Metallic State

A simple but sufficiently accurate qualitative picture of the metallic state and of the nature of the metallic bond may be developed by a comparison of the structures of a typical non-metal with a typical metal. Structurally, a metal is essentially a regular arrangement of positive ions—metal atoms without the outer valence shell—held together by a matrix of negative potential. This results from the resonance of electron pair bonds among a greater number of atoms than there are bonds. The significant fact is that the valence electrons are relatively free to move about among the metal ions, in contrast to the firmly held electrons in ionic and covalent bonds. The remarkable heat conductivity and electrical conductivity of metals are, therefore, most natural; and since there are no definite, rigid bonds between atoms in the metal, the plasticity of metals is to be expected. The bonds are self healing after rupture.

Any introduction to crystal chemistry should include a brief description of fibers. A fiber is an aggregate of crystals or long chain molecules in more or less perfect preferred orientation. Thus, if a pile of match sticks is raked sufficiently in one direction all the matches will line up parallel to each other and to the direction of raking. A fiber has been formed. Fibering is produced by nature or by man in similar ways: by cold drawing a wire, by stretching rayon when plastic and allowing it to dry under tension, by stretching rubber, or catgut, or wool. An elementary knowledge of fibers is desirable because they have directional properties of sufficient magnitude to be important in controlling their uses. Regardless of the chemical nature of the fiber, be it copper, steel, cellulose, silk, wool, tendon of human or lobster, gelatin, rubber or synthetic resin, as the orientation of the structural units approaches perfection, tensile strength increases, brittleness, resiliency and stiffness increase, chemical reactivity, elongation and shrinkage decrease.

To summarize: the structural units of which crystals are built are ions, atoms, radicals or molecules. The principal types of forces holding them together are ionic, covalent, metallic and molecular. The properties of solids depend upon their structure, particularly upon the nature of the bonding forces. Many important industrial materials are fibers, and the directional properties of fibers are accounted for by their structure.

### Crystal Chemistry for Cultural Courses in Chemistry

Whatever the difficulty in finding room for crystal chemistry in the already overcrowded introductory course in chemistry, it would appear that the elements of crystal chemistry belong in the cultural course, designed to arouse in the student an appreciation of things chemical.

To create in the mind a lasting picture of the inside of solids in general, and how this internal structure affects the properties which measure the importance of these solids in the layman's world, seems more important than to learn how to prepare a number of solids and how they react under specific conditions. Certainly, the latter will not be remembered long, while the former may.

To picture the metallic state so that one realizes why a metal differs from other solids in these mechanical and electrical properties which make metals so valuable to society would appear more necessary, if something must be omitted, than to know where the different metals are found, how they are obtained from their ores, and how they react with nitric acid.

To understand those structural features common to all fibers which make silk, wool, cotton, cold rolled steel, copper wire, catgut, rubber bands and a host of others the valuable materials they are, seems more desirable than a detailed study of ions and the theory of ionization, to pick an example more or less at random.

### Background of Value in Teaching Introductory Chemistry

The following illustrations, selected more or less at random, suggest that a more detailed knowledge of crystal chemistry affords a useful and interesting

A. Crystal chemistry leads to a clearer understanding of certain groups of compounds with which students deal. Cases in point are:

1. The work of the Braggs and others in the systematization of the silicate minerals.
2. Structure analysis of organic compounds. Establishment of the tetrahedral carbon atom and the planar benzene ring as fundamental building units. Precise determination of bond lengths and deductions therefrom concerning the nature of the bonds.
3. Clarification of the metallic state and the nature of metals and alloys.

B. There is an interesting philosophical implication in some of the results of crystal chemistry. With the help of the quantum mechanics it seems to be dulling the sharpness of some of the lines of demarcation which have usually been taken for granted.

1. The crystalline characteristics of some fibers are due solely to a parallel arrangement of long chain molecules. There is no regular arrangement of structure in the cross section of the fiber. Is such a material to be called crystalline or amorphous?
2. Where is the line between compound formation and adsorption? Any freshmen used to be able to define a chemical compound without difficulty, but recently it has been said: There is a chemical bond between two atoms when the forces acting between them are such as to lead to the formation of an aggregate with sufficient stability to make it convenient for the chemist to consider it as an independent molecular species."(2)
3. Has the law of definite proportions been relegated to the status of a definition of a restricted

2. Linus Pauling: *The Nature of the Chemical Bond.* Cornell University Press, Ithaca, N. Y., 1939.

*Continued on Page One Hundred and Nineteen*

# The Scope of Geology

● **By Timothy C. May, Ph. D.** *(Catholic University)*
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*This is the first of three articles to be written by Dr. May on the general subject of geology, a science about which most high school teachers know far too little. The other articles of the series, "Earth Dynamics" and "Applied Geology", will appear in early numbers.*

*In the present paper the author discusses some of the fundamental principles underlying the study of geology. He deals briefly with the history of geology, and then proceeds to divide the science into its two chief branches, theoretical and applied geology. The main branches have subdivisions, each of which he considers in turn.*

*There is much of value to science teachers in this article. No one can afford to overlook it.*

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Before embarking upon a voyage of scientific investigation, one is naturally interested in the benefit to be derived from such an undertaking. Obviously, the life of the modern human being is too short and too crowded with events to waste any of it in fruitless efforts.

All men are called upon by society to fulfill two primary obligations; the utilitarian and the sociological. The former is measured by the individual's ability properly to support himself and those dependent upon him, and to contribute something substantial to the economic fabric of society as a whole. The latter requires the maintenance of one's integrity with himself and the rest of society, and the ability to understand one's environment. Though by no means unique in this respect, geology helps man to fulfill these requirements singularly well.

A knowledge of geology is extremely valuable to the agriculturist, the miner, and the engineer. In the last few decades geology has been so highly practicalized that geological advice is sought before undertaking many projects of extremely great importance. As to the sociological value of geology, it might be said that geology brings the individual in closer contact with his environment than any other science. It teaches one to observe the very ground he walks upon; it teaches the tourist to understand and interpret the scenic wonders that encompass him; it teaches one to appreciate the profoundness of the earth's past history.

In its largest sense, geology is the study of the earth and its inhabitants. The latitude of this subject is so large and so intimately bound up with the life of man that it has occupied a place in the minds of philosophical investigators throughout the ages. Geological allusions can be traced back to the ancient Babylonians, but it was probably the early Greeks who first qualified their hypotheses with a semblance of thoughtful investigation. Xenophanes, born in 614 B.C., is reported to have noted shell remains high up in the mountains, distant from the shores of any existing sea. Herodotus, about 440 B.C., noting similar remains far up the Nile, publicly announced that these remains could not be adventitious but must signify that the area in question had once been inundated by the sea. Possibly the first recognition of evidences of physical changes in the upheaval and depression of land, of the excavation of valleys by running water, and of the fiery state of the earth's interior was by the Greek mathematician Pythagoras (about 500 B.C.).

The first Roman writer of note in the field of geology was probably the learned historian and geographer Strabo (about 20 B.C.). Strabo noted the relative fluctuation between land and sea and wrote about a new volcanic island in the vicinity of Thera. Seneca, born almost at the dawn of the Christian Era, also showed geological talent and spent much of his time in the investigation of earthquakes and vulcanism. Later, the crown of research fell upon the head of the elder Pliny (23-79 A.D.), who showed a great interest in the realm of geology. He lost his life during the eruption of Vesuvius in 79 A.D., when Herculaneum was overwhelmed by volcanic mud and lava, and Pompeii by dust, ashes, and pumice.

After the collapse of the Roman Empire, no important contributions were made to the science for a long time. Among the observers in the fifteenth and sixteenth centuries was the celebrated painter Leonardo da Vinci (1452-1519), who recognized that fossil shells were the remains of once living organisms, and indicated changes in the relations of sea and land. Probably the first truly constructive work was that of Agricola (1494-1555), in the sixteenth century. This work, entitled "De Re Metallica", was a compendious treatise upon the mineralogy, mining, and metallurgy known up to that time.

The English geologist, James Hutton, (1726-1797), has been called the father of physical and dynamical geology. It was he who first clearly demonstrated that the topography of the earth is subject to continuous modification and that mountain building, denudation, and deposition are intimately related phenomena. Though his work contained many glaring fallacies, it was so carefully and logically constructed that it served as the basis for Sir Charles Lyell's work, "The Principles of Geology", which appeared in 1830. This work might be said to mark the beginning of modern geological thought.

Geology can be conveniently divided into two major branches: the *theoretical* and the *applied*. Theoretical geology studies the various stages through which the earth has passed and is still passing. Roughly, it is

divided into the following divisions: (1) physical geology, which explains the materials of which the earth is formed and the energy factors effecting their change, and (2) historical geology, which treats of the earth's past history. Applied geology discusses the practical applications of the science. It may be divided into economic geology, engineering geology, political and commercial geology, mining geology, and the like.

Physical geology is often subdivided into structural geology, dynamic geology, physiography, and cosmology. Structural geology makes a study of the various layers of the earth's known crust and hypothesizes as to the possible condition of the earth's interior. Dynamic geology studies the forces that continually modify its surface, creating vast mountain chains, and then planing them down into flat, featureless tablelands. It seeks to explain the fiery emanations that well up from volcanoes, destroying entire countrysides. Physiography studies earth forms and topography with an intent to show their relationship to the cultural advances of man. Cosmology is a study of the early history of the earth and the relations of the earth to other heavenly bodies in the universe. Lastly, we have the more specific studies of mineralogy and petrology which study Nature's fundamental entities, the minerals and the rocks of which our earth is made.

Historical geology is a study of the earth's past history, of which the entire history of man forms but the last page. The units of time measurement employed by the geologist are extremely long in comparison to those used by the historian. Quite obviously the creation and wearing down of a mountain chain consumes an infinitely greater time than the life of a monarch or, for that matter, an entire dynasty. Though no one could ever be present at the entire process of the destruction of a mountain, examples of mountains in all stages of destruction can be easily studied by those who will but look about them. Great depths of sediments have been deposited in inland seas that no longer exist. Mighty animals have trod the earth that can no longer be found in existing jungles; yet, their bones have been preserved in mute testimony of their sovereignty. In the Triassic sandstones of Wyoming the bones of gigantic reptiles have been found that bring to mind the mythological dragons of old. Professor Lull has spoken of these fierce dreadnaughts as the "stalking terrors" of their time, and the mighty battles that they fought in the pursuit of their livelihood must have been epical. Again, the fronds of palms and ferns have been dug up in the Tertiary sedimentaries of Greenland, which is now a land of ice and snow. Surely this sphere of ours, with all its appearance of mock stability, has witnessed many strange sights in its many years of existence, and it still reminds us, occasionally, of its internal unrest by its volcanic mutterings and its periodic earthquakes.

The old idea of the bearded and bespectacled geologist who roamed about promiscuously chipping off useless bits of rock with the aid of a curiously designed hammer, is a thing of the past. Geologists still collect specimens, but not in the haphazard manner that many people are accustomed to believe. Specimens properly collected and labeled tell a story that may be of great economic value. Today, when a dam is built, a geologist is first consulted regarding the choice of a site. No matter how carefully the engineer may build his structure, if nature has not provided a stable foundation, his work is doomed to failure. The parable of the "house that was founded upon a rock" is especially important in projects of this nature. Again, when a company wishes to invest money in a mining project, they do not start to dig holes promiscuously with the hope of stumbling inadvertently upon a vein of gold. Gold has a tendency to form certain mineralogical companionships, much as do human beings. It might be said that a mineral is often known by the company it keeps. All these things come under the heading of applied geology and the proper answers to them can only be obtained through careful scientific study and the application of common sense. Thus, we see that applied geology is an active, practical subject upon which a large portion of a nation's wealth may depend.

One branch of applied geology is known as economic geology. This makes a careful study of the economic wealth stored within the bosom of the earth and suggests means for making them available for utilization by man. So important is this to the well-being of a nation, that most great countries employ large staffs of men to explore and classify their respective economic resources. The United States Geological Survey and the Bureau of Mines operating under the Department of the Interior are organizations of this kind.

Political and commercial geology is in many respects similar to economic geology except that the point of view is different. Here, as in the previous instance, economic wealth, both metallic and non-metallic, is the basis of study. In this study, however, the principle of barter, and international relationships enter. Political and commercial geology involves a great deal of statistical data, and such considerations as price, tariff regulations, and marketability. Society now has reached such a level that no nation is entirely self-sufficient. This is an era of specialization, and nations are not exceptions to this demand. During the recent World War the agricultural industry of the United States suffered acutely from the lack of potash, a necessary ingredient in plant fertilizers. The potash industry, previous to 1914, was almost entirely in the hands of Germany because geologists had found there the great Stassfurt deposits which knew no equal at that time in any part of the world. The United States had laboriously to concentrate inferior brines and even burn sea-weed to eke out its supply. The price of potash began to soar. The lesson was a costly one, and it inspired our government to comb the country geologically to see if we, too, might not possess a geological blessing in the form of a potash deposit of great extent. Such efforts have apparently been crowned with success. Borings in western Texas and New Mexico have convinced geologists that far under the surface of a desert waste lies a potash deposit that some day may supply "bread to the multitude".

Both the World War and the Franco-Prussian War of 1870 had much to do with geology. Geology, with its

characteristic lack of respect for the political boundary lines of nations, placed rich deposits of iron and coal on the borderland between Germany and France. For this reason Alsace-Lorraine has been and will continue to be the battlefield of Europe until the nations are willing to enter into some kind of an enduring agreement. Man needs iron, and iron needs coal in order that it may be fabricated into the forms that man desires. At present, there is much political enmity inspired by the almost insatiable thirst of humanity for petroleum.

Mining geology, as the name implies, applies geologic and engineering methods to the discovery and winning of economic wealth from the earth. Nature has not always placed the thing that man desires in the most accessible position. The miner who burrows into the earth in order to give us gold to trade with, jewels to adorn ourselves with, or coal with which to warm ourselves during the cold winter months, must be supplied with air to breathe and timbering to prevent the opening from collapsing upon him. Furthermore, since burrowing in solid rock is a costly procedure, he must have a rather definite idea about the size and shape of the hidden ore-mass before he commences to dig.

Engineering geology discusses those features of geology that are apt to confront the engineer who is trying to modify the surface of the earth rather than to explore its interior. The power of rivers must be utilized; deserts must be reclaimed by irrigation; floods must be guarded against; and harbors must be maintained and improved. These are only a few of the branches of engineering endeavor that require a geological backing.

Geology teaches us that the atmosphere can accomplish marvelous things. In the first place, it can absorb moisture; by so doing rain is made possible. Without rain, vegetation becomes impossible, and without vegetation, the land becomes a desolate waste. In the desert areas the sun beats down upon the dry and thirsty soil, and the wind currents caused by the unequal heating of the unprotected areas snatch up the abrasive sand particles and hurl them against the projecting eminences of rock abrading them, etching them, and, eventually, gnawing them into nothingness. Much of the sand is blown into piles called sand-dunes which have an unhappy facility in migrating from point to point, burying the struggling forests which seek a foothold upon the borders of the desert area, and then capriciously passing on leaving death and destruction in their wake.

In the more highly watered areas, the atmosphere picks up large quantities of moisture in one place only to drop it in the form of rain in another. The rain precipitated on the sides of mountains aggregates into mighty streams which carry large masses of rock debris in their turbulent channels, planing them down, and forming mighty canyons. Eventually, great mountain masses are eroded away and the land is carved down in featureless peneplains. Thus, the atmosphere in one place may be a mighty agent of destruction, whereas in another area where it gives rise to great forests, it may act in an entirely constructive capacity. The atmosphere, then, must be looked upon geologically as one of the principal dynamic agencies effecting modifications of the earth's topography.

But the atmosphere can act in a chemical as well as a physical capacity as an agent of geological processes. The corrosive effect of oxygen that is emphasized in the study of chemistry, is carried on in a larger way in the realm of geology. The chemical constituents of which rocks are formed are subject to oxidation as well as to mechanical disintegration. For example, the minerals of which a piece of granite is composed can in time weather away into sand and clay, giving rise to the large masses of grit and mud of which some of our sedimentary rocks are formed. This material finally washes into streams. There it is assorted into various substances in its progress toward the ocean, where it finally lodges upon the seacoast giving rise to beaches. All these things are accomplished slowly and more or less unobtrusively, and yet with a certitude that brooks no impediment. There is reason to believe these processes have been going on for millions of years in much the same fashion that they are going on today. The processes of geology are leisurely but astonishingly consistent.

The study of geology is in no way mystical. It requires a reasonable knowledge of the fundamentals of chemistry, physics, and biology; an ability to make careful, intelligent observations; and a certain amount of common sense. Let us take a simple example. Geologists have agreed that the northern part of the United States has suffered severe glaciation in relatively recent times. As it is difficult for the uninitiated to picture an ice-cap, such as that which now covers Greenland, to have extended as far west as Montana, and to have penetrated from the north as far south as upper Missouri and southern Illinois, let us investigate some of the phenomena that have convinced geologists that this must have been so.

We shall confine our attention to the lobe that covered all of the New England states, practically all of New York, and the northern part of New Jersey and eastern Pennsylvania. The southern limits of this sheet extend from Martha's Vineyard westward through the entire length of Long Island and Staten Island, and thence across northern New Jersey in the vicinity of Plainfield, to Pennsylvania. From this point it swings northwesterly through Pennsylvania toward Lake Erie, and then into Ohio.

In order to start our discussion, we need go no farther afield than New York City. The so-called "back-bone" of Long Island rises from the otherwise flat and featureless topography as a mass of loose and heterogeneous sediments. In it there are fragments of rocks plucked from the many and diverse formations lying to the northward. Some of these have been transported even from Canada. This more or less continuous ridge, paralleling the longer diameter of the island, obviously marks the southern limit of the great Pleistocene glacier in this area. The heterogeneous nature of the materials that it contains bears a marked anal-

*Continued on Page One Hundred and Twenty*

# The Correlation of Religion and Science in the Teaching of Science

• **By Sister Mary Andrew, S. S. N. D.**
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*True science and true religion are not antagonistic. On that point there is now rather general agreement. "Science is God's thought discovered by man."*

*Instead of conflicts there is harmony. In the classroom the teaching of religion and of science can be correlated to the advantage of both.*

*Sister Mary Andrew, who has thought much about how the teacher can "bring God into the science laboratories", here gives practical advice and suggestions as to procedures.*

*This paper was presented at a recent meeting of the Chicago Catholic Science Teachers Association.*

The purpose in life of every religious teacher should be two-fold: the sanctification of self, and the salvation of others. Naturally, she endeavors to teach religion whenever the occasion arises. The science teacher in particular, has numerous opportunities at her command to lead her students from the consideration of the things of nature to "Nature's God". She must carefully plan the manner in which to accomplish this end, and the aspect of Religion which she wishes to teach in this way.

The worthwhile teacher is the one who in her teaching correlates the various branches of learning, and thus broadens the horizon, and gives greater meaning to the fund of knowledge at her disposal.

But what about the correlation of Religion and Science?

The concluding paragraph of an article written by Sister Mary Claver, O.S.F., entitled "The Cultural Value of Science" and printed in the March, 1936, issue of the *Science Counselor*, states, "Every Catholic teacher makes it a point to correlate Science and Religion and to lead the student from an appreciation of the universe to an intense love of the Creator Who has made all things according to weight and number and measure." Do all Catholic teachers bring God into the science laboratories, or do they in a large number of cases close the door in His face? Perhaps the author had in mind religious teachers—priests, brothers, and sisters. From experience I can cite an example of a Catholic lay teacher of biology, who, when the students themselves expected some reference to the Creator, would merely state that no one was able to give an adequate explanation of certain phenomena.

But should the Catholic science teacher teach Religion during the science period? While I was discussing this question of correlation with a certain English teacher, she informed me that she teaches more Religion during her English periods than during the time set aside for Religion. If the same can be said for science and Religion, would it be right for the Catholic science teacher to allow to pass unheeded this opportunity of making God the basis of her teaching? Schmitt and Perkins in the text, *Faith and Reason*, make use of numerous scientific references to teach Religion. The science teacher could just reverse that order, using Religion to strengthen scientific theory, laws, and phenomena.

Probably the best way to drive home a point of Religion during the science class is to take the student by surprise, because what is said is then more apt to leave a lasting impression. To be able to do this there must be preparation on the part of the teacher. She should, however, avoid over-stressing religious aspects or assuming a didactic attitude; otherwise she may do more harm than good. Students might come to dislike not only their science classes and everything scientific, but their Religion as well.

Would it be a good plan to make formal assignments correlating Religion and Science? I do not know of anyone who has actually followed such a procedure, nor can I speak from experience as having done so myself. However, in teaching the history of science such work could be done in connection with the biographical study of outstanding Catholic scientists.

Beginning with the very definition of science, reference can be made to Religion by adding to the regular explanation that "Science is God's thought discovered by man." All laws of science, whether biological, chemical, or physical, are laid down by God, and we, in our study of them, may delve into His secrets.

In the General Science class, a study of the universe reveals its immensity, and emphasizes the small place occupied by our solar system. The harmony existing between the heavenly bodies and the movements of the earth proclaims the omnipotence of God. This same idea may be stressed in viewing the tiny snowflakes, no two of which are exactly alike.

Either in the chemistry or the physics class an analogy may well be drawn between the structure of the atom and the organization of the solar system.

St. Thomas Aquinas has given us a very important conclusion with regard to matter—namely, that "Nothing at all will ever be reduced to nothingness." It was not until the nineteenth century that chemists and physicists realized the truth of this principle, and passed it on to us as the Law of Conservation of Mat-

*Continued on Page One Hundred and Seventeen*

# Ignacy Mościcki, the Chemist

• **By John F. Matejczyk, M. S.,** *(Duquesne University)*
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*Everyone knows of martyred Poland's recent determined fight to defend her territory against the unprovoked attacks of Hitler and Stalin. Everyone knows, too, of the dire results of the struggle.*

*Not everyone knows, however, that Poland's former President is an important scientist as well as a courageous statesman, with numerous achievements in science to his credit.*

*Professor Matejczyk relates some of the less well known facts of ex-President Moscicki's life, and discusses his more valuable scientific accomplishments.*

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Ignacy Moscicki, former President of Poland, the son of Faustyn and Stefanja z Bojanowskich, was born in Mierzan on December 1, 1867. He received his elementary education at Plock and at Warsaw. In 1887 he entered the Polytechnical School of Rysk and studied under Dr. Bischoff, receiving his diploma in 1891.

As a youth he was intensely patriotic and devoted himself to the cause of Poland's independence. His activities in this respect soon led to his expulsion from his native land by order of the Imperial Russian Government. Finding refuge in England in 1892, he studied and labored there for the next five years in the chemical laboratories of the Technical College at Finsbury. While in England he accepted a position at the University of Freiburg, in Switzerland, as assistant in physics to Professor Josef Wierusz Kowalski.

Practically all his time at Freiburg was spent in research in chemistry and physics, and it was here that he produced his greatest contributions to scientific knowledge. His scientific researches merited honorary doctorates from many educational institutions, including the Polytechnical School at Lwow, the Warsaw Polytechnical Institute, the University of Stefan Batory, the Sorbonne in Paris, and the University of Estonia.

In 1900, Dr. Moscicki began his internationally known work on the production of nitric acid from atmospheric nitrogen and oxygen. Very little information was available in this field and practically nothing was known of the efforts of other workers. Preliminary laboratory experiments proved the feasibility of obtaining nitric acid from direct combination of nitrogen and oxygen. The Societé de l'Acide Nitrique was organized at the University of Freiburg in 1901 for the purpose of financing a plant of 25 KW capacity for the manufacture of nitric acid. In order to operate such a plant, it was necessary to use 50,000 volts. Dr. Moscicki perfected and patented a new condenser to control this high potential. This plant was very successful and efficient in operation. Two years later at Vevey, a larger plant of 75 KW capacity was erected.

In the meantime, however, Birkeland and Eyde in Norway had published the results of their experiments on "atmospheric fixation." Their method was more efficient and gave higher yields of nitric acid, making it inadvisable for Dr. Moscicki to continue for the time being his manufacture of the acid. So he and his sponsors temporarily diverted their interests and efforts to the manufacture of high capacity condensers, and built for the radio-telegraph station on the Eiffel Tower what was then the largest condenser in the world.

Endeavoring to improve his nitric acid process, Dr. Moscicki developed a new method of producing a rotary flame under the action of a magnetic field. This necessitated the construction of a new furnace, which type of furnace has been in use in recent years in the plants of the "Azot" firm in Jaworz, Poland. In 1906, with the help of Sir William Crooks, the new process was set in operation and the acid obtained was equal in quality to that of the Birkeland-Eyde process.

In 1908, Dr. Moscicki supervised the construction of a plant of 2000 KW capacity at Chippis which produced 98% nitric acid. By 1910 the capacity of the plant was increased tenfold, a blessing to Switzerland during the World War as it made her independent of the natural deposits of salt-peter in Chile.

In 1912, Dr. Moscicki was appointed professor of physical chemistry and electrochemistry at the Polytechnical School of Lwow. He took with him from Switzerland a large amount of equipment which he had obtained from the Societé de l' Acide Nitrique and donated it to the school.

During the short period preceding the first World War, he organized a new Institute of Electrochemistry at Lwow. With the outbreak of the war, he was assigned to the department of munitions by the Austrian government. In spite of his numerous war-time duties, aided by Wladyslaw Szajnok he organized the "Metan," an institute for technical research, especially in the fields of petroleum and natural gases. Professor Moscicki and Dr. Kazimierz Kling, the docent of Jan Kazimierz University, were appointed directors of the newly organized institute. A journal was published at the institute called the "Metan". After four years it was renamed "Przemysl Chemiczny." It developed and grew to such an extent that it became the most outstanding technological publication in Poland.

Dr. Moscicki's interest in petroleum led to the development by him of three methods for the separation of petroleum emulsions which, up to that time, had been discarded as worthless products. For his brilliant work

*Continued on Page One Hundred and Thirteen*

# Science Conference . . .

*A small part of the exhibit of pupil-made radios exhibited by the Radio Club of St. Philip and James High School, Phillipsburg, N. J., at the 1939 Duquesne University Conference. Prizes were won later at the Science and Engineering Fair in New York City.*

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Duquesne University's eighth annual one-day Conference for teachers of science in Catholic high schools will be held in Pittsburgh on Saturday, February 24, 1940.

Teachers in service everywhere, teachers in training, supervisors, executives, anyone interested in the teaching of science—all are invited to attend. Individual invitations will not be issued. *This is your official invitation to come!* You will not be lonesome. Others from your district will be among the several hundred teachers, located in the New York-Chicago district and beyond, who yearly find inspiration and aid at the Conference.

You will be well cared for. The Sisters Alumnae of Duquesne University will be your hostesses. They will provide accommodations for all visiting Sisters. When the time of arrival is known in advance, Sisters who come from a distance will be met at trains and conducted to the convents to which they have been assigned. Since a large number of visitors must be housed, requests for accommodations should be made well in advance to Sister M. Aurelia, O.S.F., President, Sisters Alumnae, St. Wendelin Convent, Custer Avenue, Pittsburgh, Pa.

There is no registration fee or charge of any kind in connection with the Conference.

The Duquesne University Conferences are under the patronage of the Most Reverend Hugh C. Boyle, D.D., Bishop of Pittsburgh. Each year he graciously welcomes the teachers. Later he spends considerable time viewing the science project material that is loaned for exhibition by many Catholic high schools throughout the country. The Reverend Thomas J. Quigley, Superintendent of Parish Schools, and the Very Reverend J. J. Callahan, C.S.Sp., President of Duquesne University, will greet the guests.

One of the features of the 1940 program will be an address by Dr. E. R. Weidlein, Director of the Mellon Institute of Industrial Research. He will speak on "Advances Through Scientific Research." A new feature of the general session will be a panel discussion participated in by four Sisters and two Brothers on the general theme "Making high school science more productive." Reverend Raymond V. Kirk, C.S.Sp., dean of the Duquesne University school of education, will act as coordinator.

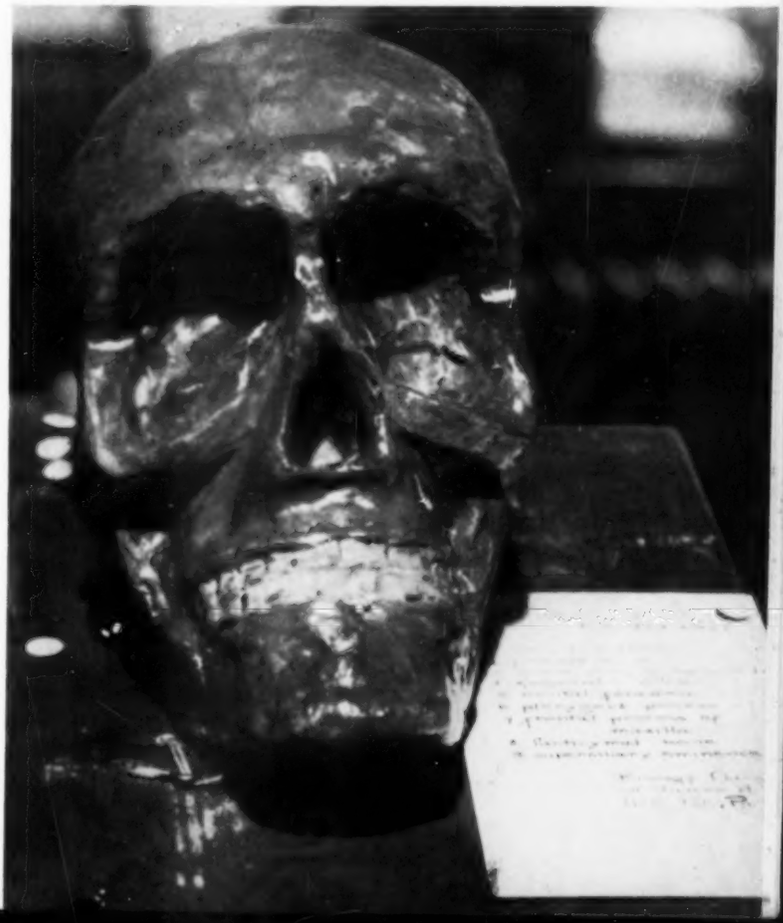
There will be demonstrations in physics, chemistry, and biology, round-table conferences in the several sciences, exhibits of scientific apparatus and student projects in science. Those in attendance will be guests of the University at lunch. Tea will be served by the Sisters Alumnae in the library during the social hour that concludes the day.

Those who are interested in the Conference should note:

There are no special invitations.
No matter where your school is located you will be welcome.
Accommodations will be provided for visiting Sisters.
Sisters will be met at trains.
Exhibits of pupil projects are solicited.
There are no fees.

As announced in our September number, prize essays on "Chemical Gardening," the soilless growth of plants, should be received not later than February 1, 1940. Project material should be sent so as to arrive in Pittsburgh by February 12, 1940. ●

*An exhibit prepared by students at St. James High School, West End, Pittsburgh.*



# Notes on Catholic Chemists

• **By Sister M. Dafrose, O. P., Ph. D.,** *(Fordham University)*
BISHOP McDONNELL MEMORIAL HIGH SCHOOL, BROOKLYN, N. Y.

*In this short paper Sister Dafrose has condensed the results of much study concerning the most noted Catholic chemists of all time. She presents it in the form of brief notes.*

*This material, interesting in itself, will prove useful to the teacher in developing a background in the history of science and in suggesting topics for further study. To one who has not made a study of the history of chemistry this paper will offer new information about important scientists and their accomplishments. Note the reference to biographical studies in Sister Mary Andrew's article on page 105.*

*The author has collected similar data about Catholic physiographers. They will be published in one of our early issues.*

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## INTRODUCTORY

**St. Albertus Magnus, O.P.,** (1193-1280) was the first eminent German chemist. His principal researches were reported in: "De Rebus Metallicis et Mineralibus"; "De Alchymia"; Secretorum Tractatus"; "Breve Compendium de Ortu Metallorum"; "Concordantia"; "Philosophorum de Lapide". He taught how to purify gold, prepare arsenic, etc. He was the first man to use the term "affinitas" to designate the action in the combination of the metals with sulphur and other elements. "Vitriol" is another term first used by him. *The Catholic Encyclopedia* states: "Albert was assiduous in cultivating the natural sciences; he was an authority on physics, geography, astronomy, mineralogy, chemistry, zoology, and physiology. On all these subjects his erudition was vast and many of his observations are of permanent value." He is a canonized saint and a Doctor of the Church, an indication that faith and science go hand in hand in their search for truth.

**Roger Bacon, O.S.F.,** (1214-1294) born in England, was one of the most remarkable alchemists of his time. His writings indicate that he knew the composition of gunpowder, and his references to inextinguishable fire indicate a knowledge of phosphorus. He succeeded in subjecting organic substances to dry distillation and noted the production of inflammable gases. He showed that air is necessary for the burning of a lamp. His chief writings are the "Opus Majus" (which advocated the use of the experimental method and the principles of inductive philosophy), "Speculum Alchymia" and "Breve Brevarium de Dono Dei". A correct explanation of the statement frequently made by certain historians that his work was hampered and forbidden by his religious superiors can be found in the *Catholic Encyclopedia*.

**Theophrastus Paracelsus,** (1493-1541), Swiss, was the first iatro-chemist. He allied pharmacy with chemistry and dealt a severe blow to alchemy.

## FUNDAMENTAL ELEMENTS (H & O) AND FUNDAMENTAL COMPOUNDS ($H_2O$)

**Antoine Laurent Lavoisier,** (1743-1794), born in France, was the founder of modern chemistry. Among his many basic contributions are:

1. The introduction of the balance into the laboratory—causing quantitative analysis to be properly estimated.
2. The discovery of the increase in weight of a metal when oxidized, overthrowing completely the phlogiston theory.
3. The knowledge that the products of combustion weigh as much as the original substance plus the weight of the matter absorbed from the air. The famous experiment by which he arrived at these conclusions is found in practically all chemistries of the present day.
4. Lavoisier called oxygen, hydrogen, and nitrogen, simple substances.
5. He also originated a nomenclature based on the oxygen theory.
6. He demonstrated the decomposition of organic substances.
7. He improved nitre manufacture, and the manufacture of gunpowder.
8. He led the way to the theory of indestructibility of matter.

He published a treatise on chemistry and about sixty memoirs. He was guillotined May 3, 1794. "A melancholy proof that, in periods of political ferocity, innocence and merit, private virtues and public services, amiable manners and the love of friends, literary fame and exalted genius, are all as nothing to protect their possessor from the last extremes of violence and wrong, inflicted under judicial forms." (Brennan: *What Catholics Have Done for Science*—p. 47)

## CHEMICAL LAW AND THEORY

**Raymond Lully, O.S.F.,** (1235-1315), born on the Island of Majorca, may have been the first to use chemical symbols.

**St. Thomas Aquinas, O.P.,** (1227-1274), born in Italy, was a great chemist, as well as a great theologian. He taught alchemy at Bologna, Rome and Naples and wrote several books on alchemy. The most important one was "Most Secret Treasure of Alchemy." He was the first to use the term amalgam for the alloy of mercury with a metal. He explained how artificial gems could be made.

**Arnold Villanueva,** (1235-1313), was born either in Provence or Catalonia. He was a disciple of the Arabian school of alchemy and believed in the composite nature of metals and their transmutation. His chief service was in applying chemical preparations to

medicinal use. He knew the curative powers of externally applied mercury compounds. He distilled essential oils, was familiar with some of the properties of alcohol and had an extensive knowledge of poisons. *The Catholic Encyclopedia* states: "His reputation in alchemy was excelled only by that of Raymond Lully who was regarded as his pupil."

### GENERAL LAWS OF GASES AND ATMOSPHERE

**Pierre L. Dulong**, (1785-1836), and **Alphonsus T. Petit**, (19th Century) French chemists, were experimenting on the specific heat of metals when they finally discovered and gave to the scientific world the fact that the specific heat of the metals is very nearly inversely proportional to their atomic weights. Multiplying the specific heats by their atomic weights gives a constant quantity. They finally stated the law thus: "The atoms of the different elements have the same capacity for heat." This formed the basis of finding the true atomic weight and proved to be of great use in chemistry.

**Edme Mariotte**, (1620-1680), a French chemist, formulated independently, the famous law: "The temperature remaining constant, the volume of a gas varies inversely as the pressure upon it", fourteen years after Boyle had published his paper. This is a significant fact to contrast with discoveries today that are known throughout the scientific world almost as soon as they are published. From Mariotte's report it is evident that he had a much clearer realization of the importance of the law than did Boyle.

**Louis Jacques Thenard**, (1777-1857), a French chemist, was the co-founder with Gay Lussac of a new method of organic analysis. He discovered boron and hydrogen peroxide and Thenard's blue so widely used in the manufacture of porcelain. He was an outstanding teacher of chemistry and during his thirty years at the Sorbonne, the College of France, the Polytechnic School, 40 000 students attended his classes.

**John Baptist Van Helmont** (1577-1644), a Belgian chemist, introduced the term "gas" into chemistry. He was the first one to make a study of gases and grouped them as inflammable and non-inflammable. He introduced chemical methods into biological studies.

### NON-METALS

**Jean Antoine Chaptal**, (1756-1832), a French chemist, professor of organic chemistry at the Polytechnic School in Paris, greatly aided the advancement of chemical manufacture. The improved manufacture of saltpeter for use in gunpowder is one of his contributions.

**Dr. M. Dolch**, (1891-1937), Austria, was Head of the Institute for Technical Chemistry in the University of Halle. He was an expert in the fields of lignite research and of the utilization of combustibles. The Carnegie Institute gave him a special grant of money to come to the United States in 1928 to conduct a lecture tour.

**Louis Pasteur**, (1822-1895), born in France, was professor of chemistry at the Sorbonne, the father of bacteriology and the founder of biotherapeutics. He established and directed the Pasteur Institute which has done so much research work in chemistry. He was famous for his experiments on fermentation, revolutionized the production of alcohols, established the germ theory which has proved so helpful in counteracting disease, made many vaccines, and by his investigations and work preserved the silk industry in France.

**Theophile Jules Pelouze**, (1807-1867), born in France was the first one to isolate tannic acid, discovered nitrosulphates, initiated the preparation of nitrocellulose in France, and inaugurated the use of sodium sulphate in glass making.

**Basil Valentine, O.S.B.**, (1394- ? ), lived in Erfurt and knew a great deal about the metals. He classed arsenic, bismuth and zinc as metals. He prepared antimony, used it in purifying gold, and used its compounds medicinally. He was the first one to prepare hydrochloric acid, made the first attempts at qualitative analysis and proved the presence of iron in hard tins, of copper in Hungarian iron, of silver in Mansfield copper, and of gold in Hungarian iron. He used the alcohol lamp instead of a furnace.

### THE NATURE OF CARBON COMPOUNDS

**Michel Eugene Chevreul**, (1786-1889), France, was the first successful expositor of glycerine. He showed that natural fats were compounds of certain acids and glycerine. He made possible the present wholesale production of soap and he replaced the filthy tallow candle of former days, the wick of which had to be constantly snuffed, by the clean stearine candle. He discovered stearic, butyric, caproic, margaric and oleic acid. In dyeing, also, he achieved eminent success. Reverend M. Brennan narrates the following:

"Some three or four years ago, the savant was passing through the little town of Dourdan, numbering two thousand souls. In the afternoon of the same day the curé entering the church, perceived an old man kneeling before Our Lady's altar, saying his Rosary. Not wishing to disturb the stranger's devotion, he simply bowed, and retired to say his office. When the old gentleman had finished his beads, he went up to the priest. Monsieur le curé," he said courteously, "you are perhaps astonished to find a stranger in your church at this hour. I am M. Chevreul, I have missed the train, and while waiting for the next I thought I could make no better use of my time than by coming here to pray to Our Lady."—*What Catholics Have Done for Science—pp. 153-154.*

**Jean Baptist Dumas**, (1800-1884), France, produced most important results in the field of organic chemistry. He investigated the chemical structure of ether, and alcohol. He studied substitution in organic compounds, showed that hydrogen in organic bodies can be replaced by chlorine, worked to find the atomic weight of carbon, and did much to establish the relation of the members of the hydrocarbon series in organic chemistry. He also made careful researches in the vapor density of the elements. Dumas fixed the number 16 as the atomic weight of oxygen and also determined many other atomic weights.

"Dumas was a consistent Catholic and remained true to his faith all his life. When it was necessary, he never hesitated to defend Christianity against the attacks of materialism."—*Catholic Encyclopedia.*

*Continued on Page One Hundred and Fourteen*

*Photograph by Robert Turnff Hance*

# NEW BOOKS

## The Teaching of Science in Elementary and Secondary Schools

*By* VICTOR H. NOLL, Ph.D., Michigan State College; Longmans, Green and Co., New York. 1939. viii + 238. $2.00.

This book, one of Longmans' Education Series, is a book that science teachers have needed. It is an important contribution to the literature of science teaching. If you would be a better teacher, study it carefully.

We quote from the preface:

"This book was written with the hope that it might in some measure contribute to the development of a larger view in science teachers. It aims to show where we stand in this field and to point out the probable directions of future progress. It aims to inculcate an appreciation of the part that research has played in improving classroom teaching, and to show what it may help us to do in the future."

Professor Noll has gathered together and "digested" the results of numerous researches in science teaching, both published and unpublished, some of which have heretofore been almost inaccessible to the classroom teacher. The material of hundreds of studies has been well sifted and sorted and arranged in usable form. Chapter headings include: Why teach science? The scientific attitude; What methods may science teaching best employ? The curriculum in natural science; The curriculum in Junior and Senior high schools; The measurement of achievement; The chief uses of tests; The teacher's qualifications.

Designed as a textbook for "methods" classes, it will be invaluable to the progressive teacher of science. It will be useful as well to general students of education.

*H. C. M.*

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## Physik für Studierende an Technischen Hochschulen und Universitäten

(Physics for Students in Technical Schools and Universities.) *By* Ingenieur PAUL WESSEL, Dr. techn. Verlag von Ernst Reinhardt, München, 1938. xii + 550 pp., 277 figs., 12 × 20 cm. Price, R M 4.90.

This text is obviously not suitable for use in English-speaking schools. It is, however, interesting to compare it with the texts used in our own schools with respect to the topics included and the relative emphasis on the various divisions of the subject matter.

The book is divided into three parts, the first two of which comprise the Foundations of Physics. In the first part Mechanics, Wave Theory and Acoustics, Heat, and Light are discussed; the second deals with Magnetism, Electricity, and Electronics and Atomistics. The third part includes a summary of the preceding material with a repetition of all the formulas, then a list of 1447 review questions, and finally a collection of 29 tables.

A striking feature of the book is the comparative brevity of the textual material. Of its 550 pages, 354 are used for the body of the text, 60 for summaries, 62 for review questions, 38 for tables, and 36 for the index. Since the pages are small to begin with, and there is in addition an average of almost one figure per page of textual material, the result is an amazing brevity of discussion. For substantiation it is sufficient to note the space allotted to several specific subjects: Newton's laws and their consequences, 10 pages; acoustics, 5 pages; reflection of light, 4 pages. On the other hand, certain subjects seem to be given a disproportionately large amount of space: Boyle's law, 5 pages, specific gravity, 2 pages; photoelectricity, 10 pages. In defense of the book it must be admitted, however, that the discussions, though brief, are concise and clear; the figures also take the place of a great many words.

Another striking feature is the failure to emphasize numerical problems. Throughout the book 106 illustrative problems, most of them very simple indeed, are solved, but not even in the list of 1447 review questions is there a single problem for the student.

One cannot avoid getting the impression that this book is designed for use in a so-called "memory course." Definitions, of which there are many, are all printed boldface, and all equations are boldface and boxed. The problems, it may be mentioned, are all printed in small type. Each review question either has the answer appended or a reference to the page in the text on which the answer is to be found; moreover, many of the questions themselves are of a relatively trivial type: What is physics? What is mechanics? How long is a meter? For what is a voltmeter used?

This text differs so greatly from the typical American text in content and emphasis that, even if it were written in English, it would almost certainly not be favorably received by American teachers.

*T. H. Dunkelberger*
*Graduate School, Duquesne University*

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## An Introduction to Physiological and Pathological Chemistry

*By* L. EARLE ARNOW, Ph.D., University of Minnesota Medical School. C. V. Mosby Company, St. Louis. 1939. 555 pp. Illustrated. $3.50.

This book, which is intended primarily for use in schools of nursing, is divided into three parts. Part I deals with the fundamentals of inorganic, organic, and physical chemistry. Part II is devoted to physiological and pathological chemistry. Part III contains laboratory experiments. Study questions are found at the end of each chapter. Thought-provoking questions accompany many of the illustrations.

The author has written a book that is readable, practical, and up-to-date. The usually dry discussion of fundamental chemical facts is made interesting by reference to common phenomena. Seemingly, formulas and equations are employed only when absolutely necessary, a practice that makes the book unsuited for use in schools where more than an elementary course is given. The beginner who studies this text will, however, obtain a broad view of the subject.

*E. P. G.*

## Discovery of the Elements

*By* MARY ELVIRA WEEKS, Fourth Edition. Journal of Chemical Education, Easton, Pa. 1939. v + 470. Illustrated. $3.50.

The popularity of this delightful book is deserved. Published first in 1934, it has now reached its fourth edition, surely a fine tribute to its excellence. The book has been considerably revised and enlarged. The 117 pages that have been added since the first printing permit the author to include numerous additional illustrations and to add new material to bring the account completely up to date. An admirable feature of the book is the extensive bibliography that accompanies each chapter.

Read this book yourself. See that that unusually capable student has a chance to become interested in its pages.

*H. C. M.*

## Standard Chemical and Technical Dictionary

*By* H. BENNETT. Chemical Publishing Company, Inc., New York. 1939. xlii + 638. $10.00.

Another valuable book for your reference shelves. Here in convenient form are found some 25,000 brief definitions of scientific and technical terms, derived for the most part, as the name indicates, from the chemical field. Many mathematical, physical, and industrial terms appear. Biological definitions are less numerous.

The pronunciation of the words defined is not indicated, but several early pages are devoted to a general discussion of the pronunciation of chemical words. The nomenclature of organic chemistry is considered at some length, and the prefix names of many organic radicals are given.

This technical word book is handy for quick reference when a concise definition rather than a lengthy treatment is desired. Teachers, students, writers, engineers, and all other workers in science will find it useful.

*H. C. M.*

## Essentials of College Chemistry

*By* G. H. WHITEFORD, Ph.D., and R. G. COFFIN, M.S., Colorado State College. Second Edition. C. V. Mosby Co., St. Louis. 1939. 534 pp. Illustrated. $4.00.

In this college textbook for beginning students, basic principles are presented in such a manner as to prepare the student for the study of any of the specialized branches of the science. By a judicious selection of the material offered, the book might well serve as a foundation for a "cultural" course. A number of improvements have been made in it since its first publication twelve years ago.

Methods of presentation and selection of material are always debatable, since opinions, not facts, are involved. Reviewer and author may not agree, yet both may be right. For example, teachers who prefer the historical approach will not subscribe to the statement that "It is necessary to minimize the historical consideration as the student does not at first appreciate the problems of the research scientist to a degree that will command his interest."

Some teachers may question the author's development of positive and negative valences in the oxides of metals. Others will consider the treatment of atomic structure as too condensed for the college student, and the study of numerous important compounds as too abbreviated. A chapter on electro-chemistry would, in the opinion of the reviewer, add to the value of the book. The Appendix contains a glossary of chemical terms, metric tables and equivalents, atomic weight table, and a table of the vapor pressure of water.

*J. F. M.*

## History of Chemistry

*By* F. J. MOORE, Ph.D. Third Edition Revised, *by* WILLIAM T. HALL, Massachusetts Institute of Technology. McGraw-Hill Book Company, Inc., New York. 1939. xxi + 447. Illustrated. $3.00.

Since the publication of the first edition in 1918, Moore's *History of Chemistry* has been considered one of the outstanding books in its field. Written in a manner that appeals to the general reader as well as to the serious student of chemistry, it discusses the facts and influences that have contributed in some notable way to the development of chemical science. The new revision by Dr. Hall is well done. The general plan and much of the original content is unchanged. There is included in the present edition considerable material dealing with the work of prominent living chemists such as, Langmuir, Urey, Lewis, Soddy, Rutherford, Abderhalden, Bergius, Nernst, Debye, Svedberg, Joliot and many others.

This book is an invaluable source of information concerning chemistry and chemists.

*J. F. M.*

## Biology

*By* BROTHER H. CHARLES, F.S.C., Ph.D., St. Mary's College, Winona, Minn. The Bruce Publishing Company, Milwaukee. 1939. viii + 408. Illustrated.

This book, prepared for use in Catholic high schools, presents in orderly and interesting fashion the nature of living things with special reference to the vital functions of man. There is a breadth of knowledge and a practicality of information that is pleasing to see in a book intended for beginners. Particular tribute should be paid to the brevity, which has not, however, interfered with the adequacy of the treatment of each subject. Illustrations are many, apt, and unusually well placed on the page.

The reviewer feels that the text of the book may be a bit above the heads of very young high school students, regardless of the excellent job of writing that has been done. The author has conscientiously kept before the reader the relation of God to the biological phenomenon under discussion, following his expressed opinion that "it will broaden and deepen his interest in God's handiwork about him." The chapter on Variation and Heredity may prove difficult for students of high school age to grasp. There seems to be a tendency to unduly weight Mendelism, although for general teaching purposes this has always seemed to me to be the best way to teach the subject. There should be made, however, special reference to the work of the great modern geneticists which has been so widely heralded. It is worth knowing, for example, that recent work done by a living geneticist has been rewarded with the Nobel prize.

The book closes with a large glossary and an ample index. It deserves consideration when a new book is being sought for high school classes, or for classes in normal schools and teacher colleges.

*Robert T. Hance*
*Graduate School, Duquesne University*

# Science and World Crisis

*Continued from Page Ninety-Six*

chisedech of the Old Testament, he seemed to be without family or country. But, fortunately, that has changed. Today, scientists are taking an active part in the social and civic and even the political life of their communities, thus bringing to these the benefit of their trained minds and high ideals. However, though, by and large, this has been a beneficial contribution, there are a few scientists who have, in my opinion, done a disservice to science by espousing radical theories and aligning themselves with subversive movements. Of course, that is their privilege as individuals, but it is questionable whether they do right by science when they use the influence of their official positions or scientific accomplishments to back up these causes. We all recall the derision brought upon science by the crackpot ideas of the technocrats and the early brain-trusters of the New Deal.

But it is in the classroom that some scientists have done the most harm. Abusing the authority of their position and the lack of resistance of the unformed minds before them, they have gloried in the work of wrecking the foundations of patriotism, morality and religious belief in their students. There is no country in the world in which there is more freedom for scientific investigation and more money provided for carrying it on than the United States. Yet there are some American scientists who are well known for their open advocacy of systems of government diametrically opposed to our own, especially the Communist, and have supported movements whose object was to undermine democracy as we have always understood it in America. They also attack the capitalistic system, though it is this system which has provided the endowments which enable them to carry on scientific work. Some, too, take particular delight in wisecracking at the religious beliefs and the old-fashioned *mores* of millions of our citizens. And any objection to these attacks by the attackees is immediately branded as a curtailment of free speech. I will repeat that, as citizens, they have the right to say what they please but, as scientists, I maintain they have a responsibility to science not to bring it into disrepute by asserting as facts what are only their private opinions, or by trying to bring ridicule upon others for not agreeing with them.

This has never been the attitude of really great scientists individually, or the official attitude of the scientific bodies. At the Boston meeting of the American Association for the Advancement of Science a resolution was passed entitled "A Declaration of Intellectual Freedom" in which the suppression of independent thought and its free expression was denounced as a crime against civilization. A committee was appointed to study the question and to recommend measures for safeguarding this freedom. When it presented its report I was in the Council as a representative of our Academy. Several prominent members of the Association advocated the addition to the original resolution of a declaration of the correlative of the freedom of science, that is, the equal responsibility of science. And this was done.

Other indications of the same were given at the last meeting of the Association at Richmond, at which the retiring president, Professor George D. Birchoff, took as the subject of his presidential address, "Intuition, Reason and Faith in Science," and Sir Richard Gregory, for many years editor of *Nature* and special guest of the American Association from the British Association, spoke on "Religion and Science." Quite a change from the days of Andrew White! For, after referring to Cardinal Pacelli's (now Pope Pius XII) address at the opening of the Pontifical Academy of Science (of which Professor Birchoff is a member) in which he spoke of "the potent streams of the natural and rational sciences and the great river of revealed wisdom," Professor Birchoff says, "As for 'the great river of revealed wisdom,' is it not to be found in all the absolutely sincere utterances of poets, philosophers and prophets . . . ? It would seem that such utterances are in essence similar to the pronouncements of the scientist . . . it is desirable to accord reality in equal measure to *all kinds of knowledge everywhere*, and so to view the universe as broadly and impartially as possible".

If this attitude is maintained and even broadened, I foresee the evolution of a mighty force for peace, justice and happiness in the world. Because it seems to me that a combination of science, with its painstaking search for and accurate correlation of facts, and of philosophy, with its insistence on logical reasoning in drawing conclusions from data and making practical application of them, and of religion, with its tremendous power to inspire the human heart to heroic deeds, would be unassailable. We have seen scientists lead the world astray because either their theories were not logically deduced from their facts or they prostituted their discoveries to bolster a political system; we have seen philosophers spinning webs of thought out of their minds absolutely divorced from reality and tending to debase man to the level of the machine; we have seen religious leaders crusading against scientific truth either because they did not take the trouble to learn the facts or because, knowing something of the facts, they felt obliged to deny their validity because it seemed to run counter to divine revelation, as if God could contradict Himself.

But if we scientists make it our aim to give the world facts unadulterated by preconceived theories, and the philosophers will come to the scientists for the facts on which to build their systems, and the theologians will interpret revelation in the light of demonstrated scientific findings, then, instead of wasting our time in useless controversy and weakening one another's position in the battle for freedom—political, intellectual and religious—we can present a solid front to the forces both of error and of tyranny. And no dictator, whether he be communist or fascist, would be able to prevail against us. For when the supernatural inspiration of religion is added to the natural power of the human mind, men will be willing even to lay down their lives for scientific truth as they have and still are laying them down for religious conviction. ●

## Ignacy Moscicki

*Continued from Page One Hundred and Six*

in petroleum refining and in the production of gasoline from natural gas, the Polytechnical School of Lwow conferred on him an honorary doctor's degree.

It was at Lwow that Dr. Moscicki developed a method of obtaining sulfuric acid from sodium sulfate, a method of concentrating nitric acid, a process for the separation of aluminum oxide from clay, electrolysis of sodium chloride by means of mercury, and a method of obtaining sulfur from gypsum. Dr. Moscicki served as consultant in the construction of a refinery at Jedlicze, Poland, the capacity of which is 200 tons daily. The method used at this refinery is now being universally adopted by American refineries.

In June, 1925, Dr. Moscicki was chosen rector of the Institute at Lwow. He was honored further by his appointment to a professorship at the Warsaw Polytechnical Institute. Dr. Moscicki is the founder and an honorary member of the Technical Academy at Warsaw, and is an active member of the Polish Academy of Sciences in Krakow. He is the author of more than fifty publications distributed among Polish, French, German, English and American journals.

This great Polish chemist and patriot was elected President of Poland at the national convention in June, 1926. As President of Poland, he found less time for scientific research. However, during recent years he has been able to effect the development of methods for the air conditioning of schools, hospitals, and other large public buildings. These methods he donated to his country. And so it has been with Dr. Moscicki all his life. He has unselfishly devoted himself to his country and to chemistry,—the science he loves so well.

In a message to the Chemical Engineers of the World, in convention at London, he expressed his ideas on the importance of the chemical industry to the world at large when he said: "Nothing is more characteristic of the development of the civilization and economic life of a country than the extent of the output and the variety of the consumption of products manufactured by the chemical industry. . . . . For these reasons every country, and Poland, of course, too, is making great efforts to develop its chemical industry and to provide the best instruction and training for chemical engineers."

Proud Poland has been invaded by the hordes of Hitler and Stalin. Her territory has been stolen. Her former President, now 72 years old, is a refugee in Rumania. ●

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●

## IN FUTURE NUMBERS

A few of the articles which will appear in early issues are the following:

**Science Experiences with Ten-cent Store Equipment**
*By* CARLETON J. LYNDE, Teachers College, Columbia University, New York.

•

**Can the Student be Made to Want to Learn Science?**
*By* OSCAR L. BRAUER, San Jose State College, San Jose, California.

•

**Academic Preparation of a Science Teacher**
*By* RUFUS D. REED, New Jersey State Teachers College, Montclair, N. J.

•

**Why Form a Science Club?**
*By* SISTER M. AIDA RYAN, O.S.F., Madonna High School, Aurora, Ill.

•

**Does High School Chemistry Function in College?**
*By* HAROLD A. IDDLES, University of New Hampshire, Durham, N. H.

•

**Bartholomew**
*By* JAMES J. WALSH, Noted Author, New York City.

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**The Science of Fire Protection**
*By* WILLIAM H. EASTON, Technical Director, Safety Research Institute, New York City.

•

**Biological Drawing and Logical Thinking**
*By* J. P. GIVLER, The Womans College, University of North Carolina, Greensboro, N. C.

•

**Vitamin K, the Anti-Hemorrhagic Vitamin**
*By* VICTOR E. LEVINE, Medical School, Creighton University, Omaha, Neb.

•

**The Sociological Value of Insects**
*By* SISTER AGATHA, S.S.C.M., Our Lady Academy, Manteno, Ill.

•

**Respiratory Protection**
*By* E. W. GILLILAND, Mine Safety Appliances Company, Pittsburgh, Pa.

•

**The Catholic Round Table of Science**
*By* REV. FRANCIS P. LEBUFFE, S.J., New York City.

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**Rayon**
*By* J. BRACKEN JOHNSON, New Bedford Rayon Co., New Bedford, Mass.

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**Modern Alchemy**
*By* T. H. DUNKELBERGER, Graduate School, Duquesne University, Pittsburgh, Pa.

•

**Tricks with Magnets**
*By* GEORGE E. DAVIS, Department of Physics, Duquesne University, Pittsburgh, Pa.

# Catholic Chemists

*Continued from Page One Hundred and Nine*

**Eugene Waldemar Hilgard,** (1833-1910), was born in 1833 in southern Germany. He passed brilliantly through the very severe and strict training the German boys of his time received, and very early in his college career became interested in the study of soils and crops. He had been brought up a strict Protestant, but through the example of several Catholic families he met while he was in charge of the laboratory of the Smithsonian Institute at Washington, he became a convert. Repeatedly during his subsequent career he declared that this gift of faith was the greatest event in his life, and that it had enriched his life as nothing else had.

Shortly after his conversion, he centered all his attention on agricultural chemistry. He was the first to introduce scientific principles into cotton growing. He made a study of the soils of California in connection with their native vegetation and to the results of his studies, more than those of any other person, probably, the success of California in agriculture and horticulture is due. He became the "Nation's acknowledged expert" on alkali soils and their reclamation, and the change of the "Great American Desert" into the flourishing region it is today is traceable to him. Toward the close of his life, the great American universities vied with European universities in bestowing honorary degrees upon this truly great scientist. He reckoned this as mere dust and ashes compared with his religion, and said that his membership in the Church gave him more satisfaction than any honors that could be bestowed upon him. His last years were spent in assisting Catholic charitable enterprises.

**Pierre Joseph Pelletier,** (1788-1842), born in France, did notable research work on vegetable alkaloids, and was the co-discoverer of quinine and strychnine.

**Louis Nicholas Vauquelin,** (1763-1829), born in France was the discoverer of chromium, beryllium, camphoric and quinic acids and asparagine.

## THE METALS AND THEIR COMPOUNDS

**George Agricola** was born in Saxony in 1495 and died at Chemnitz 1555. He was a physician by profession but devoted much time to his favorite studies of geology and mineralogy. He contributed particularly to the advancement of metallurgy and the industrial arts in which he introduced many improvements. His chief work was "De Re Metallica". As Venable writes: "He was the first, and for a long time the only industrial chemist, and his book is very useful in giving a clear account of the conditions of the various industries in his day, and the different methods and operations in use then."—*History of Chemistry*—p. 46.

**Antoine Cesar Becquerel,** (1788-1878), born in France, was one of the leading chemists of the period. His researches in electro-chemistry have justly earned for him the title of founder of this branch of chemistry. Aluminum, silicon, glucinum, galena, malachite, calcareous spar, dolomite, metallic phosphates, crystallized silica are a few of the new substances Becquerel obtained or studied by means of electricity. "His character is best described by the chemist Dumas: "Becquerel loved his country, his science, his family." Fizeau ends his funeral oration with these word: "He died with the serenity of a sage and the tranquillity of a good man, with confidence in God and the immortal hopes of a Christian."—*Catholic Encyclopedia.*

**Henri Sainte Claire Deville,** (1818-1881), born in France, began his career with research in organic chemistry and contributed to the discovery of aniline dyes, but his chief work was done in inorganic chemistry. His labors were of great practical fruitfulness. He is recognized as the discoverer of the chemical phenomenon of dissociation which has contributed greatly to our knowledge of the mechanism of chemical reactions. "If aluminum is today an industrial product, this is due to the French chemist Henry Sainte Claire Deville, who has left a name famous in nearly every department of chemistry and metallurgy."—Kneller —*Christianity and the Leaders of Modern Science*— p. 217.

**Dr. Francis E. Engelhardt** was an assistant to the great German chemist Wöhler. In 1860, he taught chemistry in the College of St. Francis Xavier, New York City. He did a great deal of work on petroleum and also on the salt industry, and wrote a yearly article for the Annual Report of the Superintendent of the Onondaga Salt Reservation, Syracuse.

**Flannery**—The most revolutionary advance in the steel industry in recent years was the incorporation of the metal vanadium as a steel alloy. (*Catholic Builders* III p. 193.) The development of this scientific discovery was due to two American Catholic men, James J. Flannery and his younger brother, Joseph M. Flannery, both of whom have died in recent years.

The difficulties of mining vanadium ore in Peru in a district thirty miles from any kind of transportation and 16,000 feet above sea level would have seemed an insurmountable task to most men. Despite all obstacles, however, the two brothers pushed the proposition and secured the services of those most competent. Soon all high speed tool steels contained vanadium. "It was classed as one of the most essential war materials by the United States government and was practically withdrawn from commercial use. It was used in armor, for warships, tanks, cars, motor-trucks, gun-shields, helmets, machine gun garrels, gun mounts, submarine parts, airplane engines, etc." After the war it found an increased field in the industrial world. Both men were actively interested in all the important religious and charitable institutions in Pittsburgh.

**Charles Anthony Goessman,** born in 1827 in Germany, came to the United States in 1857 to take the position of chemist at the Eastwick Sugar Refinery in Philadelphia. He had been assistant professor to Wöhler, the great German chemist. Professor Goessman was interested in the salt industry. In 1868, he became Head of the Chemistry Department of the Massachusetts Agricultural College in Amherst and did extraordinary work there.

"He was a devout Catholic, a daily attendant at Mass and a much loved character." (*Catholic Builders* III p. 218.)

**John La Farge,** (1835-1910), the American painter, devoted years of his life to the study of stained glass

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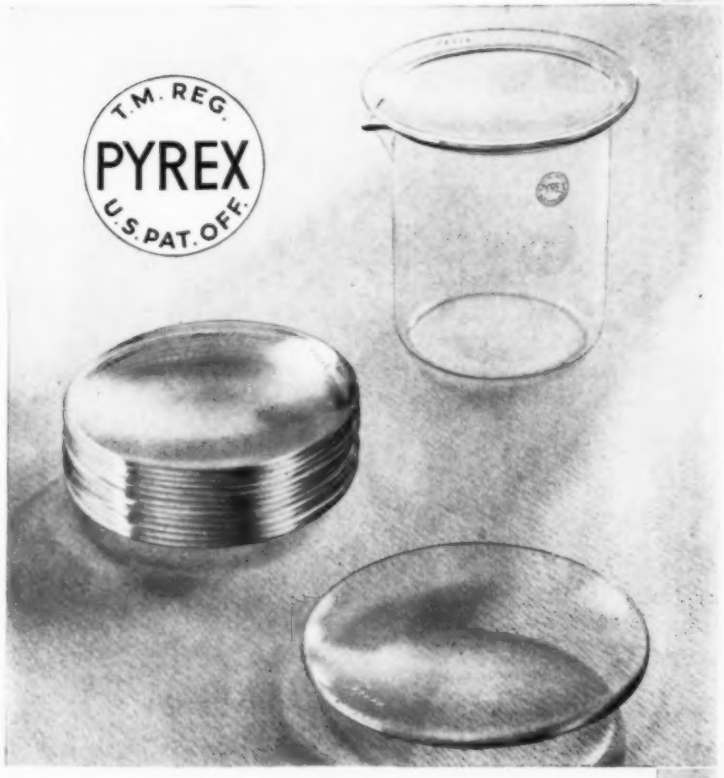


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in order to reproduce once more the magnificently colored glass of the Middle Ages. He succeeded in inventing an opalescent glass and used original methods of superimposing and welding his materials. The greater amount of the advance in American stained glass is traceable to his work. The "Battle Window" at Harvard and the "Peacock Window" in the Worcester Art Museum are two of his masterpieces. His pamphlet on "The American Art of Glass" is unsurpassed.

### APPLIED CHEMISTRY

**Rev. Julius A. Nieuwland, C.S.C.,** (1878-1936), was born in Belgium and came to the United States in 1880. He was professor of chemistry at the University of Notre Dame. In cooperation with the chemists of the duPont Company, he perfected a method for the production of artificial rubber. He succeeded in combining the simple hydrogen and carbon atoms of acetylene with chlorine forming a complex arrangement with properties remarkably like those of natural rubber (synthetic rubber). It is now manufactured by the duPont Company and is sold commercially under the name of Duprene.

### MODERN RESEARCH IN CHEMISTRY

**Antoine Henri Becquerel,** (1852-1908), born in France, discovered "Becquerel's Rays," that is, the invisible radiations from uranium. He is the founder of the radioactivity theory.

**Marie S. Curie,** (1867-1934), born in Poland, and baptized a Catholic, spent most of her life in Paris. Attracted by the uranium researches of Becquerel, she and her husband, Pierre, started the research that led to the isolation of the precious element radium once forty thousand times as valuable as gold and still a prize weapon in the early treatment of cancer. Physics revised its nineteenth century concepts; scientists flocked to the humble garret in Paris. The coveted Nobel prize—$40,000—was theirs. In 1904, Pierre was run over in a street accident and died from its effects. Marie continued the work, took over Pierre's teaching post, resuming the lectures where he had stopped, and proceeded with the education of her daughters, Irene and Eve. In 1911, she received the Nobel Prize for Chemistry. In 1914, during the World War, she equipped a fleet of radiological cars so that the wounded might be helped by X-rays. Always she was the student, the unselfish searcher into the realms of the unknown Concerning this great woman who spent all her life in poverty, Albert Einstein has said: "Of all celebrated beings, Marie Curie is the only one whom fame has not corrupted."

**William K. Roentgen,** (1845-1924), born in Germany; while working at the University of Wurzburg discovered X-rays, now called Roentgen rays and gave the impetus to the study of radio-active substances. He also made discoveries concerning the conduction of heat in crystals, electromagnetic rotation of polarized light, absorption of heat rays by different gases, etc. He received a Nobel Prize in 1901.

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## Religion and Science

*Continued from Page One Hundred and Five*

ter and Energy, by which we admit that God alone is the Creator of all things.

In the physics class the teacher has a splendid opportunity to teach the Providence of God by drawing to the attention of the students the exceptions to the various laws, such as the one which states that objects expand when heated and contract on being cooled, except when water is being cooled between 4° and 0° C. The expansion at this temperature causes the ice to float on the lakes and rivers and thus protects the fish and plant life. The best place to learn obedience is in a science laboratory where the laws of physics never fail.

Law and order are taught by noting that all things, including the elements, have a definite place to fill as is shown in the study of the Periodic chart. In connection with the teaching of chemistry, I would like to mention a comparison made by a student in her paper on the "Relation of Chemistry and Religion". In substance it is as follows: Just as oxygen unites with all the more common elements except fluorine, so God unites Himself with all persons except the soul in mortal sin; and as oxygen unites more readily with certain substances rather than with others, so God bestows His graces on certain members of the Mystical Body rather than on others in proportion to the amount of sanctifying grace. The person, who is governed by circumstances rather than by principle, might be compared to the amphoteric elements, those without a backbone.

Biology offers a broad field for correlation. Here again the Providence of God may be noted in the instincts of animals and their life habits. When studying cells, some very worthwhile and interesting comparisons can be made relative to the Doctrine of the Mystical Body. If one cell, or a group of cells, in the human body becomes diseased, the entire body suffers in some way. The body is healthy if all cells function properly. It is the same in the Mystical Body, the Church. If a cell is diseased the entire Body suffers; and if a body increases in sanctifying grace, the entire Church benefits by it. It is almost impossible to teach the structure of the cell and living protoplasm without admitting the existence of the soul. Through the study of living things, one is brought to realize that God directs and governs all, and has made all for us.

In biographical study we seem not to get beyond the three great names; Pasteur, Mendel, and Fabre. Why not go back to the Middle Ages, so often referred to unfairly as the "Dark Ages", and point out to the student the monumental work of St. Hildegarde,—her *Physica*, comprising every branch of natural science. Men like Roger Bacon, Albertus Magnus, and Thomas Aquinas have left us numerous volumes on scientific subjects. Nor should Copernicus, Galileo, Volta, Galvani, and other eminent scientists be overlooked. For further information on this subject, read Chapter X of Dr. James J. Walsh's book, *The World's Debt to the Catholic Church*. Study his other books, *The Thirteenth, the Greatest of Centuries, The Popes and Science*, and *Catholic Churchmen and Science*.


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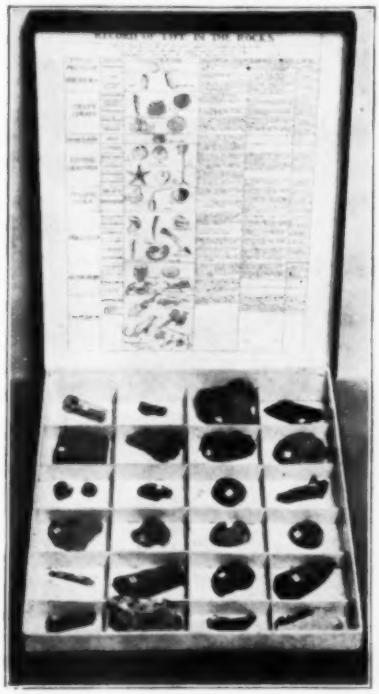

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## Unit on Insects

*Continued from Page Ninety-Nine*

5. Dixon, R. and Brayton, E. *Personality of Insects*, Charles W. Clark and Co., New York, 1924.
   Plates are very good, topics rather peculiar: may prove interesting.
6. DuPuy, W. A. *Our Insect Friends and Foes*, 1925.
   Splendid for young students. Story or essay form. Fine questions at end of chapters.
   Fig insect, bumble bee, mayfly, gipsy moth, ant, honey bee, praying mantid, Japanese beetle, silk worm, cockroach, wasps, insects in general.
7. Fabre, Jean-Henri. *Insect Adventures*, Dodd, Mead and Co., New York, 1924.
   Excellent for young children.
8. Ibid. *Life and Love of the Insect*, A. & C. Block, Ltd., London, 1918.
   Reading excellent, informal. Illustrations are fair.
9. Ibid. *Marvels of the Insect World*. D. Appleton-Century Co., New York and London, 1938.
   Interesting ways of certain insects, butterfly, ant, etc. Illustrations fair but not descriptive.
10. Herrick, Glenn W. *Insects Injurious to the Household*, Macmillan Co., N. Y., 1926.
    Information and illustrations are very good. Excellent for study.
11. Hermes, W. B. *Medical and Veterinary Entomology*.
12. Holland, W. J. *Butterfly Book*.
13. Ibid. *Moth Book*.
14. Howard, Leland O. *Insect Book*, Doubleday, Page and Co., New York, 1908.
    Plates of Insects are excellent.
15. Howes, Paul G. *Handbook for the Curious*, G. P. Putnam's Sons, New York, 1936.
    Introduction to Phyla, sponges, jellyfish, worms, etc. Insects, reptiles, etc.
    Splendid, informal, not detailed, modern.
16. Lubbock, J. *Ants, Bees, Wasps*.
17. Lutz, Frank E. *Field Book of Insects*, 1927. Exceptionally informational.
18. Needham, J. G. *Elementary Lessons on Insects*, 1928. Very good.
19. Pickwell, Gayle. *Insects*, 1935. Drawings excellent, informational, an asset to any library.
20. Weed, C. M. *Insect Ways*, 1930. Excellent introduction to the unit.
21. Wellhouse, W. H. *How Insects Live*.
22. Wheeler, W. M. *Demons of the Dust*.

## PONTIFICAL ACADEMY OF SCIENCE

The public press announces that the first "Study Week" of the Pontifical Academy of Science will be held in the "Casina of Pius IV" from December 10 to 16. It will be dedicated to the subject: The Problem of the Age of the World. Researches will be considered that are based on: (1) movement of stars; (2) energy irradiated by stars and the consecutive evolution of stars; (3) the rapidity of reception of nebulous extragalaxy; (4) radioactive and intra-atomic processes ascertained in meteors and in the minerals of the crust of the earth.

Dr. H. H. Russell, director of the observatory at Princeton University, has been invited to participate in this Study Week.

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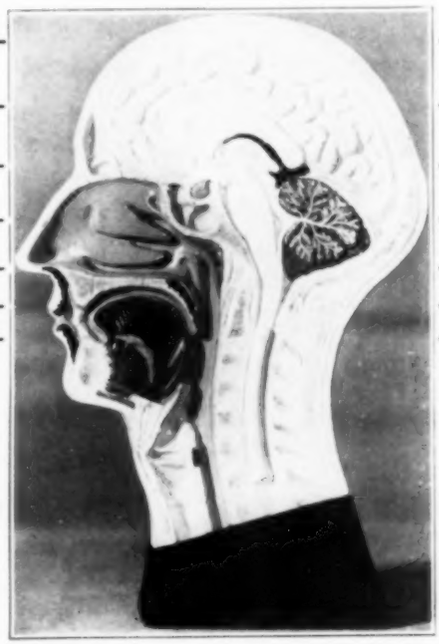

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## Crystal Chemistry

*Continued from Page One Hundred and One*

type of compound? It appears that at least the silicates and those compounds with a metallic bond could not be expected to conform.

4. Finally, even the distinction between solid and liquid has, in a sense, been dulled. The difference between the high temperature form of ammonium nitrate, with both the ammonium and the nitrate groups rotating, and molten ammonium nitrate is relatively insignificant. In the high temperature cubic form of silver iodide, although the iodide ions lie on a regular lattice and are strictly crystalline, the silver ions are said to be distributed statistically in the iodide interstices. That they have the mobility of molten silver and may, indeed, be pictured as such is evidenced by the fact that this so-called solid form of silver iodide has 10% greater ionic conductivity than does molten silver iodide.

It should not be necessary to emphasize that crystal chemistry does not pretend to render obsolete the useful distinctions between crystalline and amorphous, between compound formation and adsorption, between solid and liquid. Rather, it broadens our interpretation of them and should make it possible to teach them more effectively. ●

## Science Fair

*Continued from Page Ninety-Eight*

inspire similar activity throughout the nation. The Institute has already succeeded in establishing its club activities in twenty-eight states. It encourages those who can conveniently do so, to participate in the New York City Fair. For those located too far away for this, it furnishes suggestions for establishing local Fairs of a similar nature.

For anyone interested in this type of activity the following publications should be of service:

*How to Organize a Science Club*
*How to Plan a Science Congress*
*Announcement of the 12th Annual Science and Engineering Fair*
*Science Observer* (a monthly paper)
*Science Leaflet*

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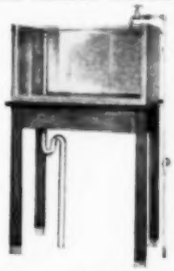

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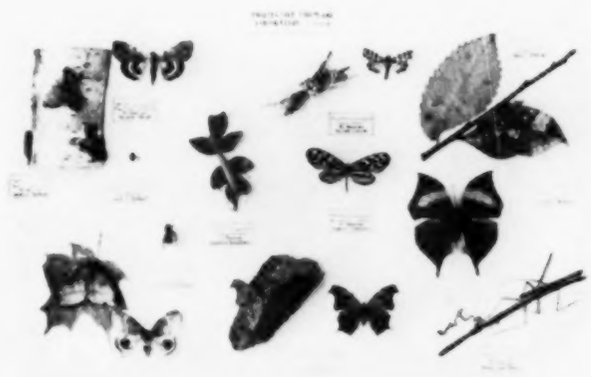

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## Scope of Geology

*Continued from Page One Hundred and Four*

ogy to those found at the end of existing glaciers where the materials, frozen in the ice, are ultimately aggregated in an unassorted pile at the foot of the glacier. Such a mass of glacial debris is termed a *terminal moraine*. To the south of the terminal moraine are found water-laid sediments carried by the streams that arose from the melting of the ice, whereas to the north, extending up into Canada there is a thinner layer of glacial debris similar to that found in the moraine proper—the so-called *glacial drift*. Thus, the soil in New York and New England is largely of the transported type and does not blend gradually into the solid rock as is the case in the South.

In Manhattan, in places that man has not as yet covered with buildings, one can observe a series of rocks outcropping that have been scoured down to smooth prominences. These prominences, which jut forth like little islands from a sea of drift, all bear marks of abrasion as though gouged by some powerful abrasive. The scorings that have been engraved upon these rock masses show marked parallelinity and point approximately due north and south. They are known as *glacial striae*. Similar markings can be found in the Adirondack region and in various parts of New England. Throughout the entire glaciated area the striae show a northerly trend. The top soil is foreign to the area in which it is found. In all instances the valleys have been broadened, and the drainage interfered with by the uneven disposition of the ground moraines which have been dropped in irregular piles wherever the stony material happened to be when the ice finally melted and retreated. Thus, strange though it may appear to us at the present time, the fact that New York was once covered by a sheet of ice seems undeniable.

From the foregoing brief description of the fundamental principles underlying geology, one can see some of the mighty features that enter into the study of geology. Its sphere of action is the earth, the air above, and the waters under the earth. It deals with pressures running into thousands of atmospheres and temperatures running into thousands of degrees. The duration of its experiments may run into millions of years. It affects the organic and inorganic world alike. The same forces that supply the blessings of life to man may deprive him of the existence it has made possible. Its forces can be described and classified, but they are beyond the powers of human explanation. ●

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# Index to Volume V
# 1939

Articles are listed under author's names. Book reviews are listed under the name of the author of the book. (R) indicates a book review. The name of the reviewer follows in parentheses.


AMON, J. C., Choosing Chemistry Textbooks in Pittsburgh ..... 34

ANDREW, SISTER MARY, The Correlation of Religion and Science in the Teaching of Science..... 105

ANOTHER BIRTHDAY ..... 1

ARNOW, L. E., "An Introduction to Physiological and Pathological Chemistry", (R) (E. P. Guth) 110

BARRY, FRANCIS, Initium Finisque..... 61

BEAUCHAMP, MAYFIELD and WEST, "Science Problems", I, II, (R) (H. C. Muldoon)..... 54

BENNETT, H., "The Chemical Formulary", (R) (H. C. Muldoon)..... 53

BENNETT, H., "Standard Chemical and Technical Dictionary", (R) (H. C. Muldoon)..... 111

BOWDEN, D. W., JR., The Science and Engineering Fair of the American Institute of the City of New York ..... 97

BRAUER, O. L., "Chemistry and Its Wonders", (R) (H. C. Muldoon)..... 53

BUCHSBAUM, R., "Animals Without Backbones", (R) (R. T. Hance)..... 52

BUSH, DICKIE and RUNKLE, "A Biology of Familiar Things", (R) (R. T. Hance)..... 54

CAMPSEN, H. M., JR., What Physics Text Best Suits Your Course?..... 32

CARROLL, FRANKLIN B., Choosing a General Science Textbook ..... 30

CHARLES, BROTHER H., "Biology", (R) (R. T. Hance) ..... 111

CURTIS, F. D., "Third Digest of Investigations in the Teaching of Science", (R) (H. C. Muldoon) 53

DAFROSE, SISTER M., Notes on Catholic Chemists.. 108

DEPPERMANN, REV. C. E., The Troubles of Father Time .....64

EIKENBERRY, W. L., Science as an Adventure..... 45

ELLIS and SWANEY, "Soilless Growth of Plants", (R) (R. T. Hance)..... 52

FITZPATRICK, LEO J., Criteria of a High School Biology Text ..... 33

FRANK, THOMAS V., The Microscope and Science.. 41

FRISCH, REV. JOHN A., The Habits and Instincts of Ants, Part II..... 6

GRUENBERG and UNZICKER, "Science in Our Lives", (R) (R. T. Hance)..... 54

HERVEY, LEON (With F. M. SCHELLHAMMER), The Experiment in Science Teaching..... 63

HOOVER, J. EDGAR, Scientific Criminal Detection... 35

HOPKINS, B. S. (With L. L. QUILL), Illinium, Element Number 61..... 2

HOUDEK, P. K., The National Association of Biology Teachers ..... 49

IDA, SISTER MARY, Motivation of a Unit on Insects 99

IN FUTURE NUMBERS.....19, 113

IRWIN and SHERWOOD, "General and Inorganic Chemistry", (R) (J. F. Matejczyk)..... 54

LAKE, HARLEY and WELDON, "Exploring the World of Science", (R) (H. C. Muldoon)..... 53

LAPP, WALTER S., A Conductivity Kit of Fifty Cents ..... 79

LAPP, WALTER S., Short Cuts in the Chemistry Laboratory ..... 13

LYNCH, W. A., Deep Focus Earthquakes..... 70

MADDEN, SISTER M. GERALDINE, Science Lessons and Life Problems..... 73

MANN, PAUL B., Why Teach Science?..... 11

MARTIN, BROTHER HUGH, Problems in Teaching Physics ..... 47

MATEJCZYK, JOHN F., Ignacy Moscicki, the Chemist ..... 106

MAY, TIMOTHY C., The Scope of Geology..... 102

MCNIFF, WM. T., On Classical Training for a Career in Science ..... 80

MELLANBY and EASTMAN, "Animal Life in Fresh Water", (R) (R. T. Hance)..... 52

MOORE and HALL, "History of Chemistry", (R) (J. F. Matejczyk)..... 111

MOULTON, F. R., "The World and Man as Science Sees Them", (R) (R. T. Hance)..... 52

NEW BOOKS .....52, 110

NICOL, H., "Plant Growth Substance", (R) (J. F. Matejczyk) ..... 53

NOLL, V. H., "The Teaching of Science in Elementary and Secondary Schools", (R) (H. C. Muldoon) ..... 110

OERLEIN, KARL F., Does Laboratory Physics Develop the Scientific Attitude?..... 3

PARK, ALLEE and SHELFORD, "Laboratory Introduction to Animal Ecology and Taxonomy", (R) (R. T. Hance)..... 52

PENDRAY, G. EDWARD, "Smashing" Atoms..... 9

PICKWELL, G., "Birds", (R) (R. T. Hance)..... 54

PICKWELL, G., "Deserts", (R) (R. T. Hance)..... 54

QUILL, L. L. (With B. S. HOPKINS), Illinium, Element Number 61..... 2

REIMANN, IRVING G., Collecting Fossils on the Niagara Frontier ..... 4

RIAL, DAVID W., A Course in Nature Study..... 50

SCHELLHAMMER, F. M. (With L. HERVEY), The Experiment in Science Teaching..... 63

SCIENCE CONFERENCE ..... 107

SELECTING TEXTBOOKS ..... 29

SENDROY, JULIUS, JR., Some Aspects of Blood as a Physico-Chemical System ..... 42

STALNAKER, JOHN M., Science Examinations of the College Entrance Board..... 8

STEIL, W. N., How Ferns Grow..... 75

STILLWELL, CHAS. W., An Introduction to Crystal Chemistry ..... 100

SUGRUE, DOROTHY, Cosmic Rays (1900-1938)..... 68

TO HELP YOU TEACH..... 62

TURNER, C. E., "Personal and Community Health", (R) (H. C. Muldoon)..... 53

VANDECAVEYE, S. C., Nature and Functions of Microbial Life in the Soil..... 38

WEEKS, M. E., "Discovery of the Elements" (R) (H. C. Muldoon)..... 111

WHITEFORD and COFFIN, "Essentials of College Chemistry" (R) (J. F. Matejczyk)..... 111

WESSEL, J., "Physik" (R) (T. H. Dunkelberger).. 110

YANCEY, REV. P. H., Science and the World Crisis. 94

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